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Special theme: Commemoration of the work of Roger Good – alpine and upland habitats

Fires, peatlands and an uncertain future | Restoration of damaged peat swamps | Fire in the high country

ANPC INC. MISSION STATEMENT: To promote and improve plant conservation

ANPC National Office

GPO Box 1777
Canberra, ACT 2601, Australia

T (02) 6250 9509 | **F** (02) 6250 9599
E anpc@anpc.asn.au
W www.anpc.asn.au

National Office Staff

Martin Driver, Jo Lynch, Carly Westbye

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New Zealand Plant Conservation Network

President	Sarah Beadel
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PO Box 2199, Wellington, New Zealand

E info@nzpcn.org.nz
W www.nzpcn.org.nz

Front cover: Roger Good, headwaters of the Snowy River, 19 January 2011 during an inspection of the soil erosion maintenance needs of the alpine area of Kosciuszko National Park, New South Wales, Australia. Photo: Graeme Warboys.

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Editor
Paul Adam

Editorial Team
Doug Bickerton, Kate Brown, Michelle Haby, Jo Lynch and Carly Westbye

Layout & Graphic Design
Siobhan Duffy

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Australasian Plant Conservation is a forum for information exchange for all those involved in plant conservation: please use it to share your work with others. Articles, information snippets, details of new publications or research, and diary dates are welcome. General articles on any plant conservation issue are most welcome.

The deadline for the June - August 2016 issue is 13 May 2016. The special theme for the issue is *online tools and resources for plant identification and conservation*. If you are intending to submit an article or wish to discuss possibilities, please email the editor, Paul Adam: editor@anpc.asn.au

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From the editor

PAUL ADAM

This issue is our opportunity to pay tribute to Roger Good, a stalwart of the Australian Network for Plant Conservation for many years, and one of Australia's leading plant ecologists.

Looking over Roger's career one cannot but be impressed by the breadth of his interests. He started work in the New South Wales Soil Conservation Service in that organisation's heyday as a pioneer in the establishment of permanent vegetation monitoring sites, not just in the Alpine catchments, where Roger worked, but elsewhere in the State. It is fortunate that Roger was able to continue the monitoring, and part of his legacy will be the maintenance of the plots. Alpine environments are likely to be particularly exposed to the impacts of climate change and understanding the biotic response will require both knowledge of the past and continuing close observation.

One of Roger's visions was for the establishment of a research centre dedicated to the study of Australia's mountain environments. The proposal is described in the article by Nicotra *et al.* which demonstrates that Australia has a strong research base able to form the core for the Centre. These are uncertain times for research funding but we hope the plans come to fruition.

A great deal of Roger's work involved the management and restoration of degraded and damaged peatlands. The Australian environment is not for the most part conducive to the formation of peat. This confers considerable conservation importance, both nationally and internationally, on the limited areas in the continent where peatlands occur. Unfortunately much of what peatland we do have is in a degraded state. Roger was an inspiration and encouragement to those engaged in the rehabilitation of damaged peat swamps, and Shane Grundy pays tribute to Roger's support for his work in the Blue Mountains.

One of the major threats to peatlands globally is fire, and we have become aware in recent years of the losses of lowland peat in Indonesia with the formation in most years of extensive palls of smoke arising from burning peatlands for conversion to agricultural use. This summer has witnessed devastating fires in Tasmania affecting peat and other montane habitats. This has attracted international attention. Fire is, of course, a recurrent theme in Australia, but the rarity and long-term consequences of peat fires of this magnitude have not yet registered in the public consciousness. French *et al.* discuss the threat to Australian montane peatlands from fire, with graphic photographs of the extent of the damage.

Peat has traditionally been a component in propagation soil mixes. In 2000, Sydney hosted the first peat free Olympics– the contracts for supply of all the planting material used in the extensive landscaping required a guarantee that no peat had been used in propagation. Since then, the push to phase out peat use, both in Australia and internationally, has weakened. Australia still imports peat for horticultural use, thus contributing to the damage and loss of peatlands elsewhere. There are suitable alternatives to peat available and we should all encourage their use.

Roger published frequently in *Australasian Plant Conservation*. This issue contains reprints of two of his articles which illustrate the breadth of his contributions. One, from volume 18(4), covers montane habitats, but also deals with the topic of the impacts of increased ultraviolet radiation, which is at the cutting edge of climate change research. The second, from 19(2), on restoration of power line corridors illustrates Roger's interest in ecological restoration, but also his involvement in planning for conservation, in this case of a linear feature in the landscape.

Roger had a very long standing interest in fire management, both from a theoretical and a practical perspective. The first time I met Roger was at the symposium at the Academy of Science in Canberra which led to the 1981 publication *Fire and the Australian Biota,* a book of continuing value.

Scott Mooney points out the originality of Roger's ideas about fire in montane habitats, and Philip Zylstra builds on the foundation established by Roger in his discussion of feedback between fire and flammability in snowgums.

A bibliography of Roger's many publications is being prepared, and will be available on the ANPC website. This will be a resource for all working in montane and wetland habitats.

A permanent tangible legacy to Roger will be the establishment of an alpine garden at the Australian National Botanic Gardens in Canberra. Hopefully this will, in a few years time, be one of the major attractions for visitors.

The article by Barrett and Rathbone discusses rare plant conservation and impacts of grazing in the Stirling Ranges. Viewed from the eastern states these ranges, although rugged, are not very high compared to the Australian Alps which feature in other articles, but the issue is one which is relevant to many habitats and I am sure would have been of interest to Roger. Peter Bridgewater's article on synthetic communities will, I hope, generate comment. It raises an issue of increasing relevance to conservation management, but one which surprisingly we have been reluctant to discuss. It also postulates what appears to have been a vacant niche in Australia at the time of European colonisation – temperate sandy beach strandlines. In the tropics there are a number of native species occupying this zone. Should coastal zone managers take action to conserve a plant community made up of introduced species? I am sure Roger would have enjoyed being part of the debate on such an issue.

The regular items include a Member's Profile introducing our new Secretary, Melissa Millar, whom we are delighted to welcome aboard and a report on the most recent conference of the Australian Systematic Botany Society. The next issue of *Australasian Plant Conservation* will feature a number of articles based on presentations at this symposium.

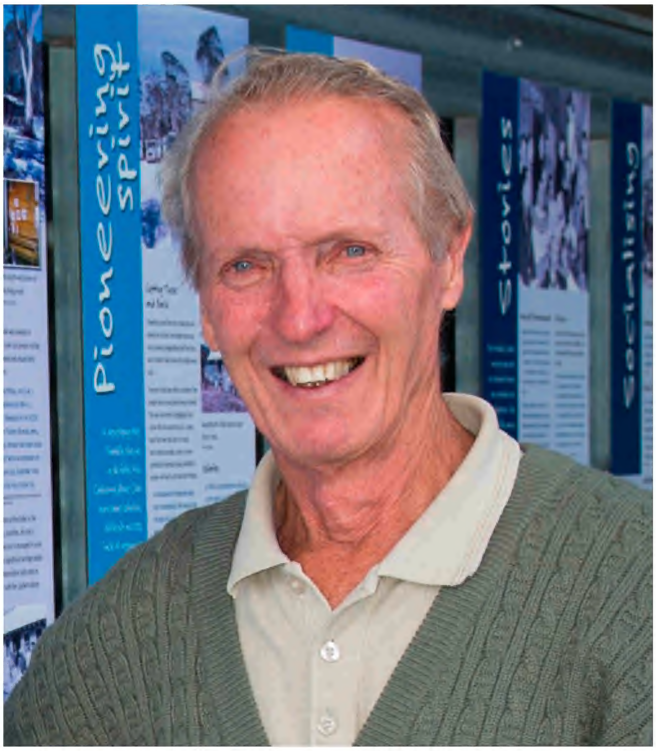
The contribution by Wood and Rudman on seed collecting from Tasmania's conifers is particularly timely given this summer's fires and the montane flavour of this issue.

Hopefully for many of you the issue will bring back memories of Roger, and, for all of you, it will be of interest and provoke thought about some current issues.

Vale Roger Good

Sadly, on Monday evening 12 October 2015, one of Australia's eminent alpine ecologists and naturalists, Roger Good lost a battle with cancer. Roger loved nature and his contributions to national and international conservation efforts during his professional career contributed significantly to a better Australia and a better planet. Roger's early professional career began in the 1960s with the NSW Soil Conservation Service where he helped manage the restoration of severely eroding catchments in the then Kosciuszko State Park.

The 120-plus year history of summer cattle and sheep grazing in the Kosciuszko mountains had resulted in severe erosion in the highest catchments. This erosion threatened the newly completed downstream dams established and operated as part of the Snowy Mountains Hydro-electric Scheme. It also threatened the loss of the alpine area's unique plants and animals. The 1960s and 1970s work by CSIRO and the NSW Soil Conservation Service stopped the erosion and restored the catchments in one of the great restoration achievements of our nation. Roger was an integral part of this Soil Conservation Service team and ultimately came to lead the alpine catchments restoration project in Kosciuszko National Park. He helped to devise and apply new techniques of soil conservation that best suited Australia's harsh mountain environments; environments that were snow covered in winter.



Roger Good, Mt Franklin Chalet, 29 January 2015 following an inspection of the Ramsar Listed Wetland and source of Canberra's water supply, Ginini Swamp, Namadgi National Park, Australian Capital Territory. Photo: Graeme L. Worboys.

In the 1970s Roger commenced work with the NSW National Parks and Wildlife Service (NPWS) and his professional contributions included early computer modelling work in relation to fire in natural mountain environments. His fire research demonstrated that frequent burning actually (counter-intuitively) increased the fuel load and exacerbated fire behaviour in the sub-alpine areas. It was the basis for a changed approach to fire management in the high country. It was also the basis for Roger's MSc thesis on snowgums and fire. Much of this work was then shared with a generation of students at both the Australian National University during the 1980's and then Orange Agricultural College where he taught courses in Fire Ecology.

Roger's NPWS work included working with an Australian Alps co-operative group and work associated with the establishment of the Victorian Alpine National Park; changes to the governance of fire management in Kosciuszko National Park (from the Hume Snowy Bushfire Prevention Scheme to the National Parks and Wildlife Service); and the establishment of the Australian Alps Liaison Committee (AALC). Cohesive management for Australia's mountain catchments that span two states and a territory was made possible by a new *Memorandum of Understanding* (MOU) and Roger Good was one of four visionaries that helped establish this MOU.

During the latter years of his time with NPWS Roger worked extensively on the NSW Water reforms and represented the Service on a number of regulated and unregulated river and groundwater committees contributing greatly to the work of these committees and to the basic water entitlements of the Murrumbidgee River system. Roger did not lose touch with the rivers of his youth and continued to provide advice to inland wetland management along the Murray and Murrumbidgee rivers.

In 2011, Roger co-authored an Australian Alps Catchments report that retraced Alec Costin's landmark 1957 Australian Alps catchments report. Some 54 years later, this 2011 report demonstrated conservation improvements to the Alp's catchments through protection and on-ground works, but it showed (in a climate-change world), conservation work was still needed into the future.

Right to the end, Roger was contributing to conservation investments in his beloved Alps and wetlands. In 2015 he co-authored reports seeking the removal of wild horses that were damaging the Alps, and he was instrumental in the formation of a consortium of researchers and protected area organisations that prepared an Australian Research Council bid for a Centre of Excellence for High Mountain Research that included mountains of the Australian mainland and Tasmania.

Roger Good, headwaters of the Snowy River, 19 January 2011 during an inspection of the soil erosion maintenance needs of the alpine area of Kosciuszko National Park, New South Wales, Australia. Photo: Graeme L. Worboys.

Roger's contributions in the Australian Alps national parks (in particular) have been outstanding. He achieved on-ground conservation restoration in alpine and wetland environments; facilitated improved science-based management, particularly for fire and wetlands, and facilitated enduring multi-government co-operation for looking after the Alps parks and the catchments they protect. His permanent legacy to all Australians is an alpine area that is recovering and has an extant, rich, diverse and spectacular Alps flora and fauna that is National Heritage Listed. He will be greatly missed.

Prepared by Graeme L. Worboys, Andy Spate, Adrienne Nicotra, Graeme Enders, Jennie Whinam and Stuart Johnston

Towards a centre for intergrated adaption research in the Australian mountains

ADRIENNE B. NICOTRA[1], JUSTIN BOREVITZ[1], MICHAEL DUNLOP[2], ARY HOFFMANN[3], JAMIE KIRKPATRICK[4], ANGELA MOLES[5], JOHN MORGAN[6], ALBERT VAN DIJK[1] AND ROGER GOOD[1]

[1]The Australian National University, [2]CSIRO, [3]University of Melbourne, [4]University of Tasmania, [5]University of New South Wales, and [6]La Trobe University. Email: adrienne.nicotra@anu.edu.au

In July 2015 an Expression of Interest for an Australian Research Council *Centre of Excellence for High Mountain Adaptation* (ARC CoE) was submitted by a consortium of more than 20 universities, industry bodies, GOs and NGOs. Together they made a diverse, multidisciplinary team that included senior scientists in the field, as well as outstanding emerging researchers, international collaborators and world leaders in the field with long-standing collaborators in Australian Mountain research. Roger Good was a key driver and architect of the bid and, in many ways, it represented a vision he held for many years that no doubt grew from his earliest efforts and experience with the New South Wales Soil Conservation Service.

Though the EOI was not successful in the 2017 round, the research network behind the bid for an ARC CoE for High Mountain Adaptation remains committed to bringing all stakeholders, including managers, regulators and the world's best researchers, together to deliver adaptation pathways in the High Mountains. Here we describe why such an initiative is critically important in Australia, the legacy on which we have the good fortune to build and what our vision entails.

Why the mountains need our attention

The world's mountains – including the Himalaya, the Rockies, the Australian Alps - define the water catchments that drive our societies, sequester massive amounts of carbon in tall wet forests and organic soils, are biodiversity hotspots and hold tremendous socio-cultural significance. In Australia, the Alps alone provide more than 35% of agricultural water valued at more than $10 billion to the national economy. This contribution is in addition to the substantial benefit to conventional, hydro- and emerging energy industries (Worboys and Good, 2011). The future of Australia's mountains thus has pervasive implications for our society as well as the environment and biodiversity.

But throughout the world, mountain systems face an unprecedented ecological crisis as a consequence of climate and land use change. In alpine regions, warming, combined with changed patterns of rainfall, is resulting in more frequent fires and pressure from migrating species, both native and exotic. Significant warming has been recorded and is on track to meet or exceed predicted rises of 3.5 – 6°C by 2100. In Australia, snow depth and duration have diminished and are predicted to decrease by more than 60% by the end of the century (Green and Pickering, 2009, Hennessy *et al.*, 2003). These effects are exacerbated by pressure from humans and, together, will have cascading effects on the unique alpine biota, with flow-on impacts to water flows, agriculture and economic stability. The ongoing security of Australian agriculture and energy industries thus relies on ensuring sustainable, functioning mountain ecosystems.

Researchers, conservation and management practitioners and other stakeholders alike recognise that historic regulation and management practices are unlikely to be effective or indeed appropriate given climate pressures. Yet, the high concentration of values in this zone creates an imperative to plan, adapt and manage mountain systems across ecological, social and economic boundaries (Sphen and Korner, 2002). Adaptation (in the evolutionary sense) is a dynamic and continual process, but at present the environment is changing so rapidly that locally adapted organisms are fast becoming locally maladapted. Therefore, it is imperative that we adopt a transformative approach to management and governance, one that is culturally sensitive, responsive, and that utilises emerging technologies to reveal biophysical effects and potential for evolutionary adaptation in natural populations (Nicotra *et al.*, 2015, Sgro *et al.*, 2011). Only a combined effort of integrated research and management can maintain biological, cultural and economic values and generate the innovative approaches to regulation and governance needed to maintain ecosystem values.

Australia's rich legacy of integrated mountain research and management

Australia has a rich legacy of long-term mountain research that provides an untapped resource for research into the effects of global change on plant communities. In the 1950's the work and research of the Soil Conservation services in New South Wales and Victoria were inherently interdisciplinary, bridging soil science, hydrology and a broad scope of ecology in pursuit of applied outcomes downstream (Robin, 1998). These efforts were crucial to the conservation of the alpine region and set the stage for the future development of initiatives like the Australian Alps National Park. This history of interdisciplinary research, that maintains and protects the natural value of the ecosystem while also incorporating diverse social pressures, is itself an important inheritance for our contemporary network of alpine researches to remember.

On an even more tangible level, vegetation plots established in the Australian Alps since the 1950s provide a unique resource. Spread across the mainland and Tasmanian high country, these have been re-surveyed over time, but on an irregular basis and the data from them is dispersed across institutions and researchers. This rich legacy of data currently resides in scattered archives, hand-written data-books, and offices around the country. We estimate these data comprise thousands of plots and transects spanning more than 70 years of data, containing data-points for hundreds of species. However, at present, it is impossible to appreciate the true extent of the data. An integrated research centre would provide an opportunity to draw this remarkable asset into a single, publicly available database that can be used as a starting point for innovative interdisciplinary investigations.

These data have not been brought into a single resource before. Failing to do so soon would not only be a missed opportunity but runs the risk of losing these assets entirely as the researchers responsible for establishing and maintaining these plots are retired or approaching retirement. Revisitation studies using historical botanical surveys as indicators of initial condition are used increasingly to assess long-term changes in vegetation (Alstad *et al.*, 2016, Vellend *et al.*, 2013). By organising the data in a publicly available database, we could provide a basis of assessing change in abundance and distribution of species as a result of land use and climatic change. There is also ample opportunity to establish a plot network for contemporary research around the existing plots (e.g. Figure 1).

A vision for an integrated mountain research centre

To produce world-leading science that can guide adaptive management of alpine and montane regions requires a shared vision and network supported both financially and physically, thus the idea for an integrated research centre. A successful centre would need to bridge the disciplinary boundaries of ecological, evolutionary and biophysical research and be inherently connected to contemporary management issues. As we see it, this can be achieved by examining each of these disciplines and their interactions. In particular we see the need to: 1) assess the effects of changing climate, water and fire regimes on ecosystem processes and their feedbacks; 2) apply innovative techniques in landscape genomics and phenotypic evolution to assist the adaptive capacity of critical foundation species, and; 3) synthesize results to effectively inform regulation, management and governance of similarly vulnerable mountain areas in Australia and worldwide. In so doing, we could deliver critical down-stream benefits in terms of water and energy security, as well as maintaining biological, social and tourism values of the regions.

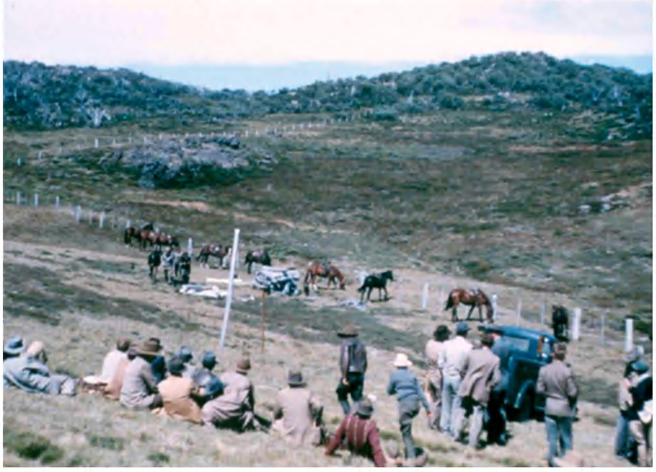
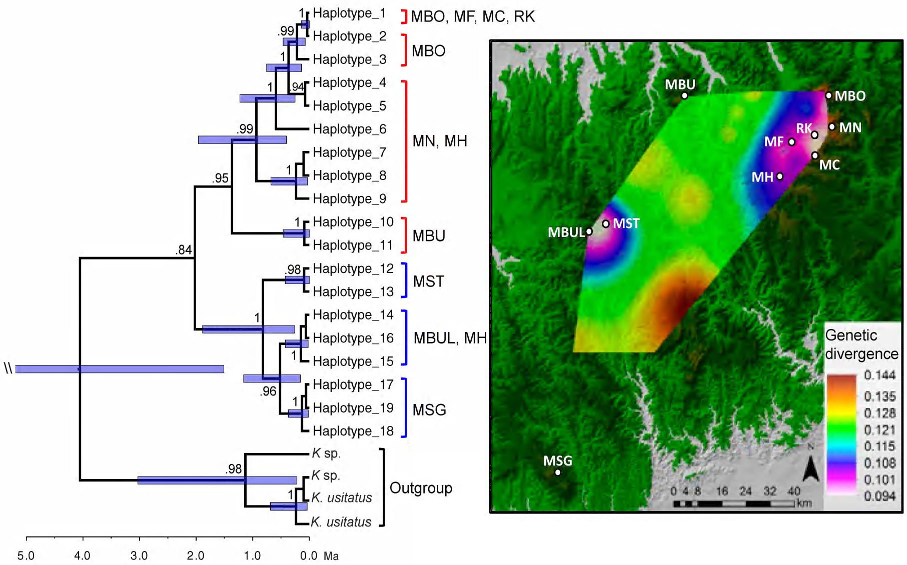


Figure 1. An integrated Research Centre would capture the assets of long-term monitoring and incorporate emerging techniques in diverse fields to yield ground-breaking biophysical and biological science. Doing so would pioneer the pathways needed to translate that science into adaptation for mountain systems in Australia and worldwide. Dr Maisie Carr's Rocky Valley Plots, 1954, are one example of the legacy of alpine research (top, Photo courtesy R. Good). To these we can add landscape-level genetic analyses to understand evolutionary history and help inform predictions of climate change response. The bottom figure provides an example of spatial and geographic analyses of genetic structure in an Australian alpine millipede (Endo *et al.*, 2015).



In our Centre bid we proposed to achieve this by establishing four inherently interlinked, interdisciplinary programs (A-D) to dramatically advance understanding and management of mountain regions and provide a powerful example for application to mountains worldwide (Figure 2). One program would examine the biotic and biophysical feedbacks in mountain ecosystems. We proposed that a process-based approach to examining water and carbon cycles, specifically examining how fire and precipitation regimes and influxes of novel biota affect ecosystems, was needed to reveal how to manage landscapes to sustain yields of water and carbon. A second program would draw on the long-term data and expert knowledge referred to above, working across trophic levels to quantify patterns of association between organisms and environment, and assess consequences of change and response at community and landscape scales. This approach, we argued, would deliver a 'whole of system' understanding of major species interactions and ecosystem consequences of changes therein. We further proposed to explore the evolutionary side of adaptation pathways by applying emerging techniques in landscape genomics and phenotypic evolution to quantify and improve capacity of foundation species to adapt. Integrating, informing and synthesising the other programs was a program building toward informed governance, planning and management. The aim of that final program would be to take a social perspective on adaptation by determining the best approaches for implementation of adaptive strategies in the domains of science, society and governance. The program would work to provide fundamental insights and support removal of societal and institutional barriers.

What becomes clear in considering the current pressures facing the Australian mountains is that the scope of this challenge requires a transformational paradigm shift and an integrated, interdisciplinary vision of research and adaptive management (Dunlop *et al.*, 2012). Synergistic, novel collaborations need to be forged across fields to add value to outstanding work underway in each area, while establishing a vanguard of adaptive management research with direct benefit not only to science but also to Australian industry, the economy and society. Australia is fortunate in having a critical mass of passionate and outstanding researchers who are dedicated to achieving these goals. Many of these are very well established, or approaching the end of their careers. Thus, we are at a critical period to transfer the knowledge and expertise to a new generation of mountain researchers. By building on the solid foundations of our own research community, and bringing stakeholders, managers and regulators together, we aim to solve the multiple challenges and deliver adaptation pathways for Australia's mountains.

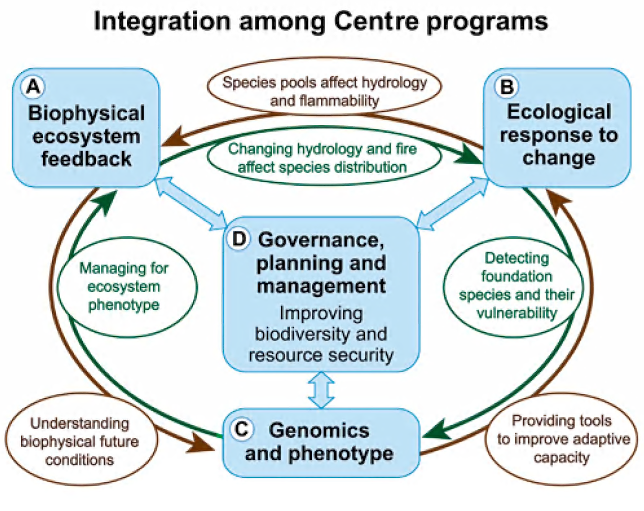

Integration among Centre programs
A
Biophysical ecosystem feedback
Species pools affect hydrology and flammability
B
Ecological response to change
Changing hydrology and fire affect species distribution
Managing for ecosystem phenotype
D
Governance, planning and management
Improving biodiversity and resource security
Detecting foundation species and their vulnerability
Understanding biophysical future conditions
C
Genomics and phenotype
Providing tools to improve adaptive capacity

Figure 2. We envision a Research Centre that integrates outstanding research across disciplinary boundaries.

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Tribute from the Australian National Botanic Gardens to Roger Good

SABRINA SONNTAG

Australian National Botanic Gardens. Email: sabrina.sonntag@environment.gov.au

Roger Good was a highly regarded colleague, mentor and friend to many staff at the Australian National Botanic Gardens (ANBG). In particular, he was also a driving force behind the Gardens' alpine plant conservation and research activities.

His leadership and participation in the Gardens' alpine-related work were pivotal in the development of the Gardens' alpine conservation program. In 2006, Roger worked directly with the seed bank and nursery staff to identify important alpine plant species that should be protected in the seed bank. Thus, the Gardens' alpine seed collecting program was born. At that time, he also provided invaluable insights for growing alpine plants.

His passion for the Australian Alps and threatened alpine communities inspired numerous projects at the Gardens and beyond. "Some of the most memorable times with Roger were working and collecting seed in the Australian Alps, this is where he seemed most proud of what he had achieved over the many years he worked in these environments. Roger's passion and drive were inspirational; he always had a smile on his face," said Craig Cosgrove, the ANBG Site Services Manager.

One major project was an Australia Research Council (ARC) project between the ANBG, the Australian National University, the University of Queensland and the Friends of the Gardens. The Gardens formalised its conservation seed collecting activities to secure alpine plants as an insurance against loss in the wild and to provide seed for novel research. Plants are secured via seed banking involving storing seed under specific conditions to extend their longevity for hundreds to thousands of years.

According to the ANBG Seed Conservation Biologist, Lydia Guja, "the total number of alpine seed collections at the Gardens now totals over 1500. More than half of these collections have been made since 2008 through a series of projects that were inspired by Roger."

Roger was also significant in guiding the development of a small experimental display garden growing alpine plants within the Gardens as part of the ARC project.

In addition to his direct input into Gardens projects, "Roger was a champion for the Gardens through collaborations with both government and non-government organisations; he had the skill to engage with people on all levels," said Craig.

"Roger was always the 'go-to' person for all things alpine. In typical Roger style, his lovely character and approach were always well-received and appreciated. Many staff considered Roger both a valued 'best-practice collaborator' and a friend," said David Taylor, the ANBG Curator of Living Collections.

"Underpinning this relationship was a huge volume of experience and expertise combined with a way of bringing people together to take on the challenging and big-picture issues that many of us struggle with.

This has left a lasting legacy in each of us who worked with Roger, enriching our well-being, and making us better custodians of our natural heritage," said David.

In October 2015 the Gardens opened a special fund in honour of Roger for the future development of an Alpine Garden.

The Alpine Garden, planned for construction in the next 5–10 years, will continue Roger's work and make a long-term contribution to the conservation of this special bioregion. This project will be unique in Australia and provide a range of outcomes relating to education, research and conservation of alpine ecosystems. Donations specifying the 'alpine fund' will be directed towards this display garden. Find the donation form at: https://www.anbg.gov.au/gardens/support/index.html

Alpine Garden Development Fund

This fund has been established in honour of Roger Good, a founding member and long term supporter of the ANPC, and an active researcher of alpine and upland habitats.

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Roger Good and the bogs and fens of the Australian Alps

JENNIE WHINAM[1] AND GENEVIEVE WRIGHT[2]

[1] Discipline of Geography & Spatial Science, University of Tasmania. Email: Jennie.Whinam@utas.edu.au
[2] Biodiversity and Wildlife Team, NSW National Parks & Wildlife Service, Office of Environment and Heritage.
Email: Genevieve.Wright@environment.nsw.gov.au

Roger Good spent over 50 years working on the restoration of alpine ecosystems, particularly bogs and fens, with his ideas and techniques evolving over this time in response to on-ground results, changing objectives and allied research. We were fortunate to share Roger's passion for peaty things and to work with him for more than two decades.

Roger thought of his 50 years of alpine restoration as one large project – particularly the work in bog and fen communities, that he described as 'water dependent ecosystems'. His early work, which ignited his passion for the conservation of the Alps, was with the NSW Soil Conservation Service on the rehabilitation and revegetation of eroded alpine lands. This was required after the massive damage caused during the grazing era. The original goal of this work was to stabilise these alpine catchments so that soil material could not damage the Snowy Scheme's turbines or flow into their dams. After completion of this major program, Roger's drive for the protection of the Alps catchments was not just confined to large restoration programs. He was interested in restoration at all scales – from restoring delicate peat walls in string bogs to restoration of thousands of hectares of the Australian Alps.

Roger was a great communicator and was at ease working with all levels of society – local landholders and councils, state and federal governments, as well as on the international stage. Roger worked with individuals, the media, corporations, research institutions, non-government organisations and community groups. He was able to bring people from all of these groups together and could instill the importance of the conservation of the Alps to a wide range of individuals. These communication skills meant that he was able to extract an extraordinary amount of institutional and corporate support for the projects that he felt were worthwhile.

Roger's great mentors (and friends) were Alec Costin and (the recently deceased) Dane Wimbush. Roger emulated their extraordinary mentoring skills and generously and enthusiastically mentored students, fellow ecologists, park managers and restoration practitioners. Roger felt this was very important to ensure a continuation of people interested in pursuing his passion for alpine conservation.

Early peatland rehabilitation programs were focused on revegetation, as it took some time to develop techniques to restore the physical and hydrological capacity of bogs and fens. Trials showed that using subsurface organic matter dams and associated techniques within the peat bogs resulted in the rewetting of dried and hydrophobic peats and assisted in retaining water during the recovery phase of these systems. When funding was provided to the NSW Parks and Wildlife Service by the NSW Premier's Department (in excess of $2.5 million) for restoration of peat bogs and fens (after the 2003 fire swept across the high country) these techniques became a practice which we were able to use to restore the physical and hydrological capacity of affected bogs.

Roger was instrumental in the completion of this major post-fire restoration program in the Alps and adopted a long-term and broad view of this restoration work. His initial post-fire observations, which we undertook with our colleague Geoff Hope (ANU), identified priorities for on-ground restoration. Rehabilitation works were completed in nine areas between elevations of 1700 and 2000 metres above sea level in 2004 and 2005, all of these sites located in the central and southern sections of Kosciuszko National Park. Initial measures involved slowing water movement through these recovering systems by the use of organic bolster dams made with sterilised straw bales and logs. These were utilised to minimise stream incision and to 'hold' water in the catchment. Other measures included the transplanting of 'plugs' of intact *Sphagnum* moss and peat to act as 'nursery beds' for bog species, and using shade to protect early revegetation from sun, UV and wind.

Roger saw this prioritisation of restoration projects as essential and was part of a group that developed an assessment process to identify priority restoration sites. This included the use of a state and transition model to assess whether the bogs/fens were likely to deteriorate if there was no intervention or whether they were likely to recover, albeit slowly, without restoration. These criteria relate to where the bogs/fens are in the landscape, how large the bogs are, how significant they are in terms of the regulation of flows into the streams in the catchment as well as an educative component of having 'demonstration sites' for managers, funding agencies and the media.

Roger felt that managing the Australian Alps for catchment values would necessarily protect biodiversity values. As Roger always pointed out, Kosciuszko National Park was initially established to protect catchment values for the Snowy Mountains, not for its biodiversity values. Roger felt it was important to value water, which is much easier than valuing biodiversity, and estimated that there is about $8-9 billion of water yield coming from the Australian Alps catchments every year, with the protection of bogs and fens in the high country critical to this water yield. These figures have helped give focus to restoration projects in the Australian Alps, particularly in bogs and fens.

Roger felt that successful restoration ecology requires lateral thinking because of the diversity and complexity of the factors involved in successfully restoring a fully functioning ecosystem. This essentially involves an adaptive management approach to restoration, including monitoring and analysing successes and failures (to determine the most effective time to establish shading; appropriate species to use for initial stabilisation; germination requirements; impacts of climate change, especially UV and impacts of the techniques being used) and constantly adjusting restoration and management practices in response.

Roger was unfailingly generous with his knowledge, giving his enthusiastic support equally to private landowners, parks and wildlife staff, land managers, CEOs, contractors, young researchers at the start of their careers and established academics. Roger shared information and provided support with grace and good humour.

Roger's vision, energy and enthusiasm was evident to all who knew him. Roger achieved significant results because of his drive and the support of his colleagues, friends and his family. Roger was tireless in working on the projects that mattered to him. His permanent legacy to all Australians is documenting the importance of protecting alpine natural values and bringing the conservation significance of the Australian Alps to the global stage. We will miss Roger as a friend, colleague and professional and will always remember him for his good humour, patience and commitment during our innumerable field trips together to the Alps.

Roger Good's role in developing restoration techniques in temperate highland peat swamp on sandstone in the Blue Mountains

SHANE GRUNDY
The Bush Doctor (NSW) PTY LTD. Email: shane@bush doctor.com.au

I was first introduced to Roger at a swamp rehabilitation workshop in the Blue Mountains of New South Wales in 2007. It was organised by the Blue Mountains City Council who were co-hosting a project called 'Save Our Swamps' (SOS).

A key objective of the SOS project was to develop locally responsive soft engineering swamp rehabilitation and rehydration techniques to restore natural swamp hydrology specifically for Temperate Highland Peat Swamps on Sandstone and Gosford Sandstone Hanging Swamp conditions. This was achieved by trialling and progressively adapting the innovative swamp rehabilitation and rehydration techniques first pioneered by Roger in the alpine bogs and fens of the Australian Alps to the local conditions found in these swamps.

As part of this project development, the expertise of Roger Good and Geoff Hope was called on to introduce contractors and council staff to some of the techniques developed during the restoration of Alpine Bogs. These techniques are commonly referred to as soft engineering, and involved the use of coir, straw, timber and jute materials. These materials are used for channel packing of incised swamps, manipulation of surface flows for the rehydration of drying swamps and the construction of subsurface dams.

These techniques have been refined over the past 8 years and modified to suit local conditions and site hydrology. On a few occasions I had questions as to whether or not trialling new techniques to suit a particular restoration area were suitable or not. On these occasions I would ring Roger at home and discuss what I was proposing. He was always willing to discuss problems and pass on his knowledge and experiences. Roger was always encouraging in his advice; commenting "there was no set way of doing things and that each site required an adaption of the basic principles of soft engineering to suit its particular needs and not to be afraid of trying new techniques or materials". This advice always gave me the confidence to take on these challenging projects, many of which were high profile restorations. There was no one else's opinion or encouragement I valued more than Roger's.

Many challenges lay ahead for the restoration of the Peat Swamps on Sandstone in the Blue Mountains. These included:

- inter agency cooperation within shared tenure,
- funds available to undertake restoration work,
- continued impact of the urban environment and its associated degrading impacts on these ecosystems,
- modifications to the hydrological processes in the Blue Mountains council area and the Newnes Plateau, and
- the degradation of the Newnes Plateau swamps through recreational use.

The pathway forward in the restoration of degraded swamps will require more adaptive restoration techniques and materials, and a better understanding of how extrinsic inputs, i.e. sediments transported by runoff, modified pH levels and nutrient loads of the water effect the restoration pathways of both vegetation and hydrological processes. There is a lack of understanding from a practitioner's point of view in the anticipated successional pathways in a regenerating swamp when dealing with the modified inputs.

Recently I have attended two Sydney Sandstone Swamp Forums. The presentation of research papers at these forums has highlighted to me the vast amount of knowledge in the academic community. There needs to be a clearer pathway for this knowledge to be available to land managers and contract workers. I would find this information valuable in the planning of works and gain a better understanding of site responses.

In summing up my experience with Roger I can only say he was always willing to give me his time and pass on his knowledge, he was a man whose opinion mattered to me and is greatly missed.

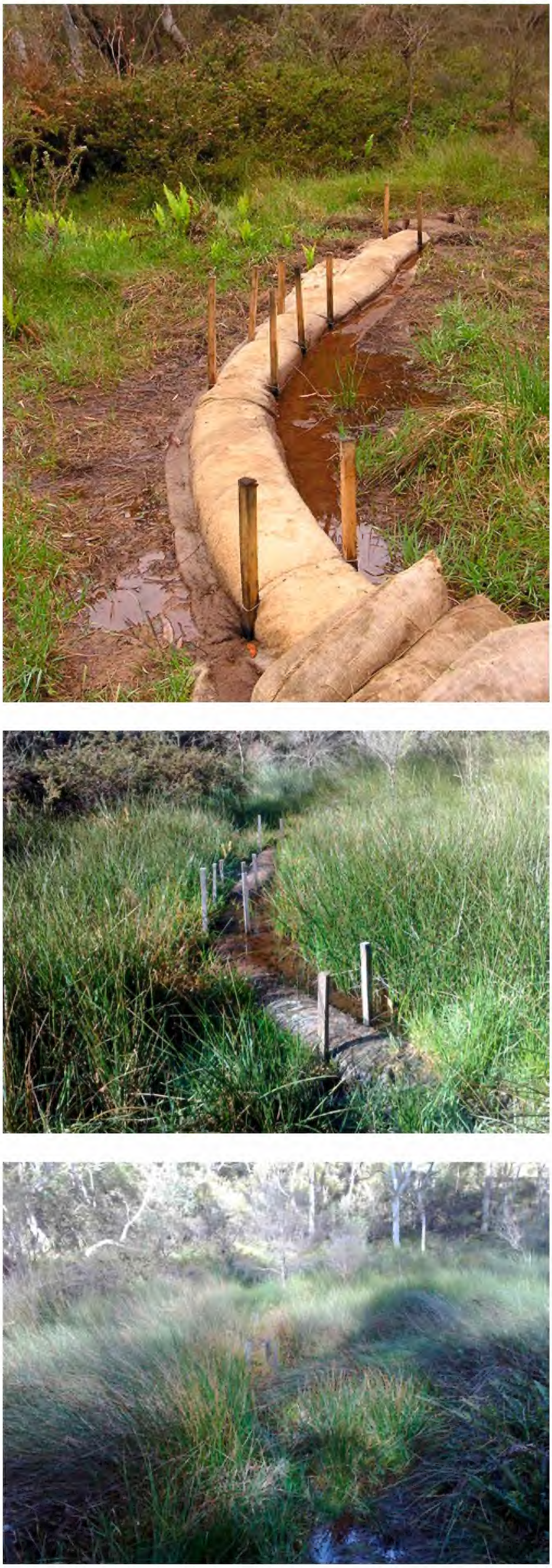
Braeside Swamp, Blackheath

These pictures are from Braeside Creek in Blackheath NSW. This section of swamp had been degraded by the associated impacts of urban runoff. These impacts included the introduction of silt into the swamp and the invasion of exotic grasses.

The silt eventually formed an elevated silt plug leading to the cutting of new flow paths around this silt plug. Eventually two defined incised channels formed on either side of the swamp. The result was a drying swamp. The lower moisture levels allowed exotic grasses such Yorkshire Fog and Cocksfoot to establish.

The restoration of this site involved the packing of a one metre deep channel with straw and coir, with a diversion structure of coir logs covered in jute diverting captured flows across the dry section of swamp.

The results of rehydration over two years were very impressive. Not only had the *Juncus* established across the site but the exotic grasses were drowned and out competed.



Braeside Swamp, Blackheath. Blue Mountains City Council. Photos: Shane Grundy

The impacts of increasing solar ultraviolet light on the wetland mires of the mainland Australian Alps

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ROGER GOOD[1], GENEVIEVE WRIGHT[2], GEOFF HOPE[3] AND JENNIE WHINAM[4]

[1]1178 Bungendore Road, Bungendore NSW. Email: rgo03227@bigpond.net.au. [2]NSW Dept of Environment, Climate Change and Water, Queanbeyan, NSW. [3]Archaeology and Natural History, Australian National University, Canberra. [4]Biodiversity Conservation Branch, Dept of Primary Industries and Water Tasmania, Hobart.

Introduction

The wetland mires of the Australian Alps were listed in 2009 as a nationally threatened ecological community (*Alpine Sphagnum Bogs and Associated Fens*) under the *Environment Protection and Biodiversity Conservation Act 1999*. This was because the area of bogs and fens has declined dramatically over the past 150 years due to grazing by domestic stock, recreation activities, infrastructure development, increasing feral animal damage and exotic weed invasion.

The bog and fen communities are widespread across the Alps with the majority of them being within the Alps National Parks. Within these parks the area of bogs and fens has declined from approximately 8500 ha pre-European settlement, to currently about 5000 ha in reasonable condition. Although many bogs and fens in the parks had recovered from past grazing impacts, the high intensity wildfires of 2003 and 2009 had a considerable adverse impact on them. Approximately 70 bogs required restoration works after the 2003 wildfires to ensure they recovered to a fully functional condition.

Climate change and changes in local climatic conditions are now the greatest threat to the survival of the bogs and fens. The predicted climate change scenarios for the Alps indicate higher temperatures, less snow and more precipitation from high intensity storm events. Already experiencing changes in precipitation regimes, increased summer temperatures, lower total cloud cover and elevated ultraviolet light levels, the Alps ecosystems have been identified in the National Climate Change Adaptation Framework (COAG 2006) as being critically vulnerable to the detrimental impacts of climate change.

Increases in solar ultraviolet radiation (UVR) is predicted to have a significant impact on bog plants, particularly *Sphagnum* (moss) species. Although solar UVR occurs as long-wavelength UV-A, short-wavelength UV-C and medium wavelength UV-B, only UV–B is significant in terms of impacts on biological systems.

Over the past decade annual total solar UV-B exposure levels have increased in the Australian Alps (Good, unpublished data) by approximately 12 per cent, partly as a response to the increased number of cloud free days but possibly as a response to the influence of atmospheric ozone depletion.

Impacts of solar UV-B increases on alpine biota

Little research has been done to identify the impacts of UVR on mire vegetation, particularly in alpine areas. Several studies in the northern hemisphere have identified amphibian populations, particularly frogs, as decreasing rapidly over recent years and identified links between these declines and increasing UV-B levels (Blaustein *et al.* 1994). In the Australian Alps, UV-B affects the Alpine Tree Frog (*Litoria verreauxii alpina*) and possibly the Corroboree Frog (*Pseudophryne corroboree* and *P. pengilleyi*), and may cause populations of these and other frog species to decline drastically with possible local extinctions at higher elevations (Broomhall 1998).

Impacts of increasing solar UV-B on *Sphagnum* bogs and fens

The bog communities are edaphic groundwater communities, essentially maintained by snowmelt and summer runoff, as well as subsurface seepage. The bogs are characterised by *Sphagnum cristatum, Empodisma minus* and *Epacris paludosa*. The *Sphagnum* often occurs as large hummocks growing over small shrubs. In sites that are not suitable for shrub growth, *Sphagnum* grows with *Carex gaudichaudiana*. In continuously wet sites where water-ponding occurs, acid fens colonised almost entirely by *Carex gaudichaudiana* are present.

The bogs and fens with free-standing surface water are predicted to be most affected by increasing UV-B, as ultraviolet light can penetrate to considerable depths in near-pristine alpine ponds (Smith 1989). Where there has been little disturbance of the bogs and fens, the pond-fringing herbaceous vegetation is shaded from UV-B by the taller herbs (*Empodisma minus, Baloskion* *australe*) and in many sites by shrubs (*Epacris paludosa, Melaleuca pityoides and Richea continentis)*. Unfortunately in the majority of bog and fen sites the fringing shrub vegetation has been lost due to past grazing and recent burning. As a result many bogs and fens have very much reduced natural shading of the significant remnant *Sphagnum* and the populations of frogs and invertebrate decomposers that inhabit the moss and ponds.

It has been recognised that *Sphagnum* species grow most readily where approximately 70 per cent shade cover is provided by other shrubs and tall grasses (Hope *et al.* 2005). With the loss of the natural shade cover as a response to climate change factors, the extent and distribution of *Sphagnum* in and around bogs and fens will continue to decline as UV-B levels increase.

Using shadecloth to ameliorate impacts

After the 2003 fires in Namadgi and Kosciuszko national parks, 70% nylon shadecloth was spread over a number of bogs (Figure 1) to ameliorate the impact of UV-B on the remnant *Sphagnum* hummocks and to promote *Sphagnum* recovery (Good 2008). This adaptive management response has to date been very successful (Dave Whitfield *pers. comm..,* Namadgi National Park) in both assisting the regrowth of *Sphagnum* and of other bog plants, particularly *Empodisma* spp.

Shadecloth has also been found to be beneficial for total biomass production. From the data derived from quadrats established to monitor *Sphagnum* recovery, after five years it was found that biomass production under the shadecloth was approximately 30 per cent higher than the biomass production for the adjacent unshaded quadrats (Figure 2). The annual total mean biomass production was 4.35 tonnes per hectare for the unshaded sites and 6.02 tonnes per hectare for shaded sites.

Summary

Changes in precipitation and runoff flow regimes from climate change may adversely impact the hydrological functioning of the alpine bogs and fens. However the high and increasing levels of solar radiation as ultraviolet light UV-B will be just as significant as it will influence the resilience, survival and distribution of the water dependent vegetation species (particularly *Sphagnum*) and amphibians (such as Corroboree Frogs) and invertebrates dependent upon the *Sphagnum* for their breeding and survival.

Irrespective of the restoration efforts of field managers to date to protect many bog and fen sites, further loss of these organic groundwater communities seems inevitable, as it is predicted that over the next 50 years the total area of mire will further decline from approximately 5000 ha to about 3900 ha of stable, fully functional bog and fen. The long-term prospect is however closely tied to the scenarios for climate change, currently reported as tracking the most extreme predictions by the International Panel on Climate Change.

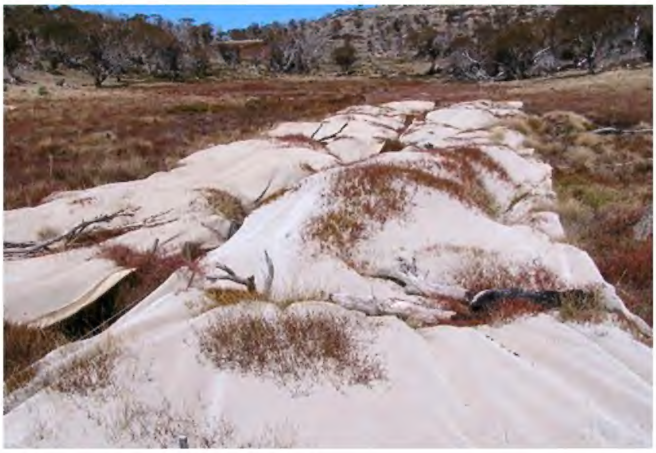

Figure 1. Shadecloth spread over a degraded bog to protect and enhance the regrowth of remnant *Sphagnum* hummocks. Photo: D. Whitfield.

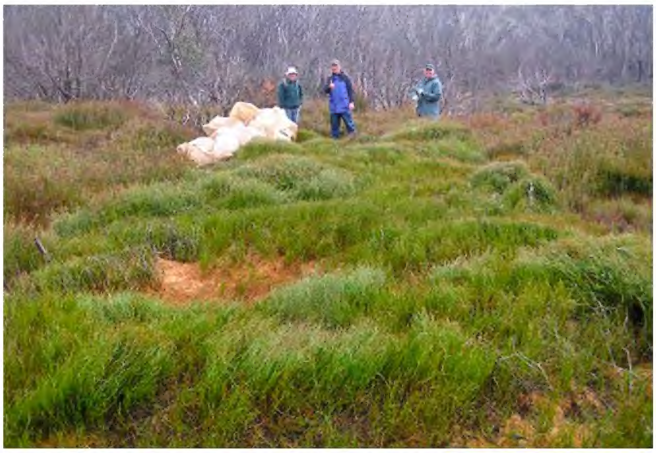

Figure 2. Shadecloth removed showing the regrowth and biomass production of *Empodisma* and *Sphagnum* species. Photo: D. Whitfield.

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Explaining feedbacks between fire and flammability in the Snowgums and beyond

PHILIP ZYLSTRA

Centre for Environmental Risk Management of Bushfires, University of Wollongong. Email: pzylstra@uow.edu.au

Changing fire regimes are gaining recognition as one of the chief impacts of a changing climate on terrestrial biota, partially due to growing awareness that the feedbacks between fire and the flammability of a forest have the potential to amplify any other changes. If we are to effectively respond to this, it is essential that we learn to understand and quantify those feedbacks as they apply in each situation.

The *fuel–age paradigm* is the assumption that recently burnt forests are less flammable than long-unburnt forests. If this is the case, then the feedback between fire and flammability is negative: more frequent fire will create a less flammable landscape and the escalation in fire will be self-limiting. Management fires can be lit under safer conditions and reduce the risk.

The efficacy of such prescribed burning can be measured from fire histories using a statistic called *leverage* (Loehle 2004), meaning the area protected from fire per area burnt. The concept began as a theoretical exercise with the assumption that recently burnt areas do not re-burn in subsequent fires. When this was modelled, burnt patches cast a shadow of protection to provide leverage as high as 11 (i.e., 11ha protected for every hectare burnt), underpinning the popular belief that prescribed burning was the practice of lighting a small fire to stop a large one.

Measured leverage values however are much lower, and to date no published study has found a value greater than one (Boer *et al.* 2016). In every forest community examined, prescribed burning is more accurately described as the practice of lighting a large fire to stop a small one. In south east Australia, leverage has in fact more often been negative than positive (Price *et al.* 2015), and this evidence of widespread positive fire-flammability feedbacks should cause serious concern.

Explaining the mechanisms

Forest flammability has frequently been related to the fuel load, or weight of dead fine fuels on the ground. These are burnt away by fire and take time to re-accumulate and reach equilibrium, so accordingly flammability should increase with time since fire and all feedbacks should be negative. This view however ignores the many other drivers of flammability (Gill and Zylstra 2005). In the Australian Alps, there has been tension between it and the observation that burning plants produce larger flames than burning leaf litter, and that fire can promote the growth of plants (Zylstra 2006). This was raised as a major criticism of broad-scale burning in montane and subalpine areas by Roger Good (1986), who noted that leguminous genera such as *Daviesia, Oxylobium* and *Bossiaea* were germinated by the very fires lit to reduce flammability (Figs. 1 & 2).

Following the 2003 bushfires, work was commenced through the NSW National Parks and Wildlife Service with the Bushfire Cooperative Research Centre to build a fire behaviour model capable of determining exactly what role plants had in the flammability of forest stands. Traditionally, fire behaviour models in Australia have been constructed from empirical data, making them reliable only for the range of fuels and conditions that had been studied. In contrast, the Forest Flammability Model (FFM)

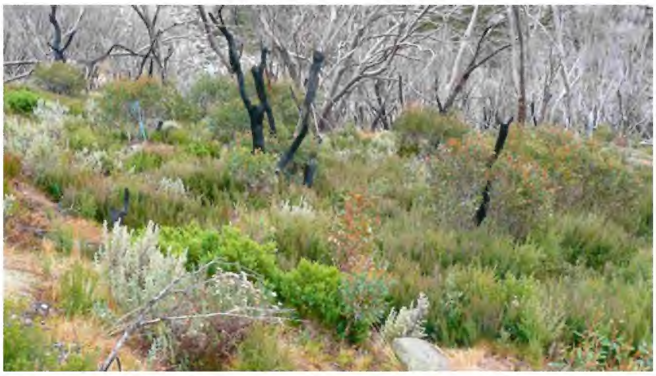

Figure 1. Subalpine woodland six years after fire (Source: Zylstra 2013)

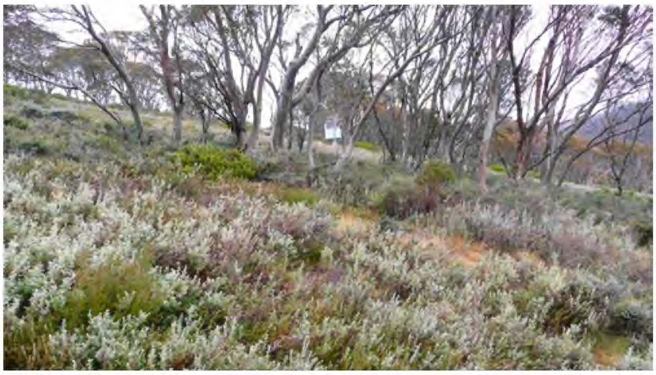

Figure 2. Long-unburnt subalpine woodland (Source: Zylstra 2013)

(Zylstra 2011) is a biophysical, mechanistic model that combines laboratory studies of leaf flammability with the physics of heat transfer, in-forest wind dynamics and the geometry of the plant community to calculate the propagation of flame from one leaf, branch, plant or plant stratum across the gaps that separate them to the next potential fuel. In this way, the FFM does not use broad assumptions to make predictions, but examines the effect of plants on flammability from an objective platform.

Testing Good's Hypothesis

To assess the utility of the model for answering questions around feedbacks, Good's Hypothesis of a positive feedback in subalpine forest was chosen as a 'risky prediction' as it countered the prevailing fuel-age paradigm. FFM modelling predicted that until Snowgum forests had regenerated a tree canopy, fires would burn faster and more frequently have large flames than in old forests. This prediction was empirically tested by comparing fire records for subalpine forest across the Australian Alps National Parks in mainland Australia. This revealed that forests which had been burnt within the previous 14 years were burnt by subsequent fires 2.3 times more often than were older forests ($p = 0.05$, Zylstra 2013). Good's hypothesis was supported by both mechanistic argument and empirical evidence: burning Snowgum forest makes it more flammable.

Wider implications

By establishing the link between plant species and the flammability of a forest, the FFM represents a milestone in the study of plants and fire. Historical work has shown that fire regimes affect plant traits and their distributions, but the FFM can now be used to study how plant traits and distributions affect fire regimes, regardless of the community (Fig. 3).

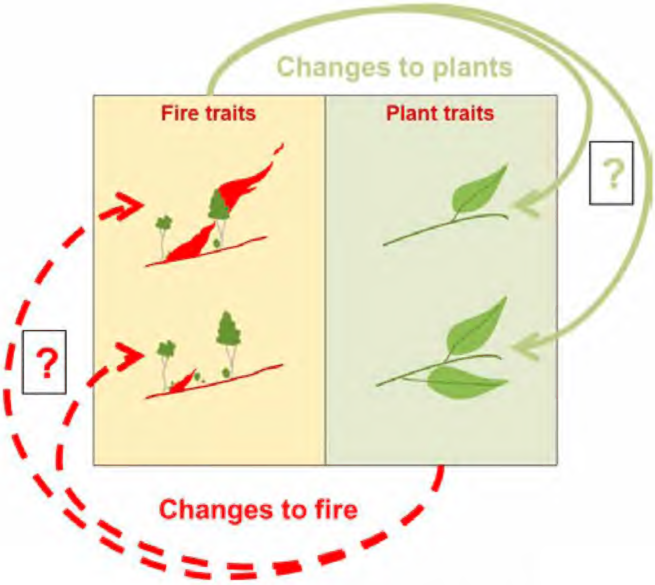

Figure 3. Fire-flammability feedbacks, completing the links between fire behaviour and fire ecology.

Conclusions and future direction

Assuming negative fire-flammability feedbacks across diverse plant communities results in under-estimation of fire-related risks, and in ineffective or counter-productive management responses where the feedback is in fact positive. The FFM is capable of quantifying these feedbacks, enabling informed, evidence-based responses.

Current work on the FFM continues in validating the model, producing software and integrating with remote-sensing technologies.

Acknowledgement

Development of the FFM has been funded by the NSW Office of Environment and Heritage, with the initial model developed as a PhD project while on staff, and subsequent work carried out as part of the Centre for Environmental Risk Management of Bushfires at the University of Wollongong. Ross Bradstock's assistance has been central to this.

Roger Good's work provided much of the initial inspiration for the development of the FFM, and during the project he provided advocacy, funds, insight and equipment. This work continues his battle for the mountains and the wild places at risk from the things we understand too poorly.

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The vulnerability of peatlands in the Australian Alps

BEN J. FRENCH[1], GEOFFREY S.HOPE[2], LYNDA D. PRYOR[1*] AND DAVID M.J.S. BOWMAN[1]

[1]School of Biological Sciences, University of Tasmania [2]Department of Archaeology and Natural History, Australian National University.
*Email: lynda.prior@utas.edu.au

Formation and function of peatlands

Peatlands are coupled to earth's wet climates (Whinam *et al.* 2003). They are formed when inundated plant material decomposes slowly relative to production, causing partially decayed organic matter to accumulate as soil. A high water table allows non-vascular *Sphagnum* moss species to prevail in many peatlands. Peatlands promote acidic soil conditions, produce decay-resistant biomass, reduce surface runoff and have an exceptionally high water holding capacity, features which stimulate further peat development. Lowering of the peatland water table can accelerate decomposition and cause a shift away from *Sphagnum* to shrubs or grass. Hence climatic drying or disturbance causing drainage can compromise organic soil accumulation. Hydrological disturbance from activities such as cattle or horse grazing can also damage peatlands through compaction of peat, increased drainage and runoff and soil erosion.

Drying also increases the impact of fire on peatlands. Fire won't burn waterlogged peats because high moisture content retards peat combustion. However, drying peats become vulnerable to smouldering ground fires, which consume the organic soil layer. Deep peat horizons are often a legacy of wetter climatic periods, when peat accumulation was rapid.

The positive feedbacks that help maintain subalpine moss cushion peatlands can be summarised as follows: saturation promotes *Sphagnum* growth and peat formation and protects from fire; upper peat layers provide good physical and chemical conditions for *Sphagnum* growth; *Sphagnum* produces resistant organic matter and chemical conditions that promote peat accumulation, and also confers fire protection; the high water storage capacity of *Sphagnum* and resulting peat soil slow runoff, promoting a high water table and saturation.

There is an opposite set of feedbacks that make it less likely for vegetation on mineral soils to convert to peatland: less organic matter reduces water retention during drought; this leads to loss of organic matter through oxidation, fire and erosion; mineral soils and drier conditions are more conducive to shrub and grassland development, less conducive to *Sphagnum* growth; vascular plants are less conducive to peat formation than *Sphagnum,* and drive higher fire frequency/severity; this leads to further loss of organic matter and promotion of mineral soils.

Together, these feedbacks reinforce the stability of the peatland/ mineral soil mosaic. However, when environmental conditions change sufficiently, or the landscape is subject to repeated and severe disturbance, the stabilising influences can be overwhelmed, and organic soils can be converted to mineral soils, or vice versa. Note, however, that conversion of organic to mineral soils can occur much more quickly than the opposite, because of the long time it takes for peat to accumulate, usually 2-5 cm per century in Australia (Hope and Nanson 2015).

Peatlands in the Australian Alps

In mainland Australia, moss-shrub peatlands are mostly restricted to the alpine and sub-alpine environments of the Australian Alps. The fact that these peatlands are constrained to poorly drained topographic positions and/or groundwater-fed systems indicates they are at the margin of climatic suitability. They are typically small (<1ha), and exist in a matrix of other vegetation types including grassland, heathland, and *Eucalyptus* woodland. They total around 7000 ha in the Australian Alps (Victoria, NSW and the ACT).

Despite their limited area, moss peatlands are highly valued, not least for their role in absorbing and releasing water into local catchments. They support numerous threatened species and contain valuable sediment records of past environmental conditions. Peat accumulation was well established in the region by 10,000 years BP, and was fastest during wet climatic periods. Charcoal throughout peat profiles indicates that fire has been common during their development, but there has been a clear increase following the change to European land management. Peatland area is estimated to have declined by at least 30% due to burning and grazing in the high country (Hope *et al.* 2012)

Management implications

The future of peatlands in alpine Australia under predicted warmer, drier climates is precarious given that they are already constrained to the wettest parts of the landscape. Predicted changes in rainfall and evaporation are likely to further reduce the area in which peat can accumulate, and will render peatlands more vulnerable to fire (McDougall 2007).

The recent string of particularly large, drought related fires in the Alps (Williams *et al.* 2008) is consistent with predictions of increased fire danger due to climate change. *Sphagnum* peatlands are the most fire-sensitive of the Alps vegetation communities; many have been burnt in recent fires, some repeatedly, with losses of peat and *Sphagnum*. Shifting fire regimes are recognised as the most rapid mechanism of degradation in drying peatlands and can potentially result in their loss (Kettridge *et al.* 2015).

Many peatlands in the region have also suffered hydrological disturbance from cattle grazing since the 1850s (McDougall 2007, Grover *et al.* 2012). *Sphagnum* is gradually recovering in some areas following cessation of grazing in 2005, but the legacy will endure for years, exacerbating the effects of a drying climate and increasing the flammability of Alpine areas.

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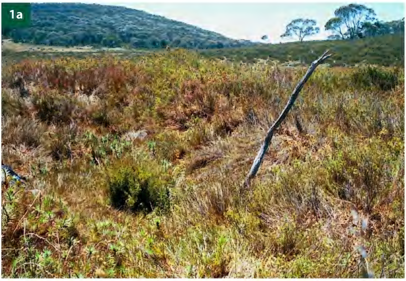

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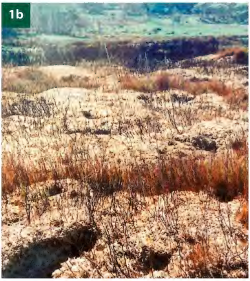

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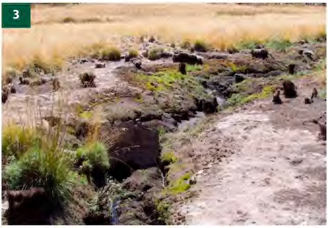

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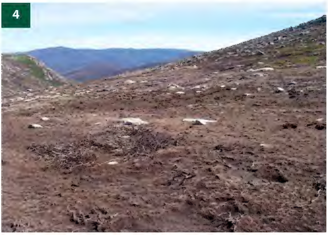

The January 2003 fires burnt over 2.1 million ha of bushland in montane south-eastern Australia including 80% of the peatlands. The fires came after three years of drought and killed the peatland vegetation, especially the *Sphagnum* moss hummocks, whose living tissue is concentrated at the surface of the cushions.
Figure 1a shows the pre-fire *Sphagnum*-shrub bog vegetation at Snowy Flat, ACT and 1b the post fire dead vegetation.
Figure 2 shows badly damaged vegetation at the Ramsar site of Ginini, ACT.
Figure 3: Peat that has been drained will burn away leaving brick-like clay, as at Top Flat ACT.
Figure 4: Alpine humus soils are particularly vulnerable, as seen at 1950 m on Mount Tate (NSW) where this picture was taken three years after the fire, with no regeneration evident and continuing wind erosion. Management here is restricted to planting tussock grass to establish some cover. Photos: G Hope.

Following disturbance, effective recovery of peatlands requires a high water table to be restored, and a disturbance-free period for *Sphagnum* to re-establish and peat to accumulate. Trials of these approaches have shown promise (Hope *et al.* 2005). Fire management targeted at conserving the least disturbed peatlands could also be effective. Regardless of the conservation strategy, optimising management requires a robust understanding of both the future fire risk and existing degradation of individual peatlands.

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The unique and surprising environments of Temperate Highland Peat Swamps on Sandstone (THPSS) in the Blue Mountains, NSW

SCOTT MOONEY* AND LEN MARTIN

School of Biological, Earth and Environmental Science, UNSW Australia, Sydney.
*Email: s.mooney@unsw.edu.au

Introduction

The Blue Mountains region, around 80 km west of Sydney, conserves a variety of unique landscapes and ecological communities in a series of National Parks which are collectively listed as the Blue Mountains World Heritage Area. This World Heritage Area contains a relatively large number of mires which have been recognised as ecologically important, for example, Temperate Highland Peat Swamps on Sandstone (THPSS), is an Endangered Ecological Community listed under the *Environment Protection and Biodiversity Conservation Act* 1999 (*EPBC Act* 1999) in May 2005 and a Vulnerable Ecological Community under the NSW *Threatened Species Conservation (TSC) Act* 1995. In the Sydney Basin Bioregion this protection under the TSC Act also extends to the Blue Mountains Swamps and Newnes Plateau Shrub Swamps both Endangered Ecological Communities, and these all share characteristics with Coastal Upland Swamps in the Sydney Basin Bioregion, an Endangered Ecological Community occurring at lower elevations, which was listed under the *TSC Act* 1999 in 2012.

In 2011 an Enforceable Undertaking under Section 486DA of the *EPBC Act* 1999 was reached between the Federal Department of Sustainability, Environment, Water, Population and Communities (now Department of Environment) and two coal mining companies over their 'significant impact' on three swamps (see https://www.environment.gov.au/news/2011/10/21/centennial-coal-fund-145-million-research-program for more information). Although these companies did not concede that they had breached this (or any other) Act they contributed $1.45 million towards the establishment of the Temperate Highland Peat Swamps on Sandstone Research Program (THPSSRP). The THPSSRP, administered by the Fenner School of Environment and Society at the Australian National University, identified priorities, called for proposals and distributed funds to support research towards better understanding THPSS and other similar mire environments.

This enforceable undertaking meant that there were at least some good outcomes resulting from perhaps permanent damage and loss of THPSS communities. The research that it has supported has focused on increasing the understanding of these unique environments and has included a focus on flora, fauna, hydrology, fire ecology and various anthropogenic impacts. Although 2016 sees the end of the formal project, the THPSS Research Group that evolved from this is currently exploring options to continue the collaboration.

THPSSRP Palaeoenvironmental research

Our projects within the THPSSRP have focused on the palaeoenvironmental record contained in the accumulating sediments of these mires. The THPSS and related communities of the Sydney Basin are often controlled by topography (topogeneous mires), in which various sediments build up sequentially through time (e.g. Fryirs *et al*. 2014). Undisturbed accumulating sediments are a natural 'archive', which when coupled with a chronology derived from radiometric dating techniques (e.g. radiocarbon (^{14}C) or ^{210}Pb) so that depth in the sediment column can be described as a function of age, can be used to 'reconstruct' aspects of the past. Careful analysis of any proxy that is sensitive to the environmental condition or process under examination allows environmental reconstruction, the examination of events, processes and trends through time, and these baseline data afford a temporal perspective that far exceeds recent historic observation and instrumental records.

Our THPSSRP research has investigated a number of sites in the Blue Mountains and on the Newnes Plateau. We have found some sites preserve relatively long sedimentary records and some include particularly organic sediments (Figure 1). The accumulation of organic sediment ('peat') is more commonly associated with cool and humid climates, when precipitation or available moisture exceeds evapotranspiration, leading to waterlogging. Subsequently, the majority of peatlands are located in higher latitudes and 90% of the global extent located in the Northern Hemisphere (Whinam *et al*. 2003).

In the Blue Mountains, a combination of altitude (up to 1100 m), relatively high rainfall (partly due to the orographic effect of the Great Dividing Range) and a sandstone lithology with relatively impervious horizontal strata interspersed with claystone and shale members facilitates the development of swamps and anoxic conditions that preserve organic-rich sediments through time. As described by Fryirs *et al.* (2014), and by our (unpublished) work the THPSS tend to have basal sand and gravels of late Pleistocene age and more organic-rich sediments start to accumulate ('paludification') in the Holocene (Figure 1). While similar depositional features must have existed in the past, especially during earlier interglacial phases, the sediments are poorly preserved over multiple glacial-interglacial cycles. Longer sedimentary records are probably available, for example associated with tectonic processes (e.g. see http://www.geomaps.com.au/scripts/bluemountainsoverview.php) but these have yet to be fully documented in the Blue Mountains "A Rich, Diverse and Dynamic Sandstone Landscape". It is generally well known that the Sydney Basin Bioregion contains an incredible floral richness, with over 2000 native vascular plant species and a wide diversity of vegetation communities (e.g. Fairley and Moore 2010). The mires of the Sydney Basin are also species rich, with estimates exceeding 200 vascular plant species (http://www.environment.nsw.gov.au/determinations/coastaluplandswampfd.htm). These species occur in a complex mosaic that is influenced by moisture characteristics (depth to water table, climate), size and disturbance including fire and anthropogenic influences amongst other things (e.g. see Buchanan 1979; Holland *et al*. 1992; Keith and Myerscough, 1993; Bell *et al*. 2005; Benson and Baird 2012).

The diversity of these vegetation communities is rarely appreciated, possibly because people don't often venture into these 'swamps': perhaps with good reason (e.g. leeches, snakes, wet and unstable surfaces) and this has positive outcomes given that some species are sensitive to trampling. In our fieldwork we have been constantly amazed by how different each of the mires can be in terms of topography/landscape position, vegetation dominance and substrates.

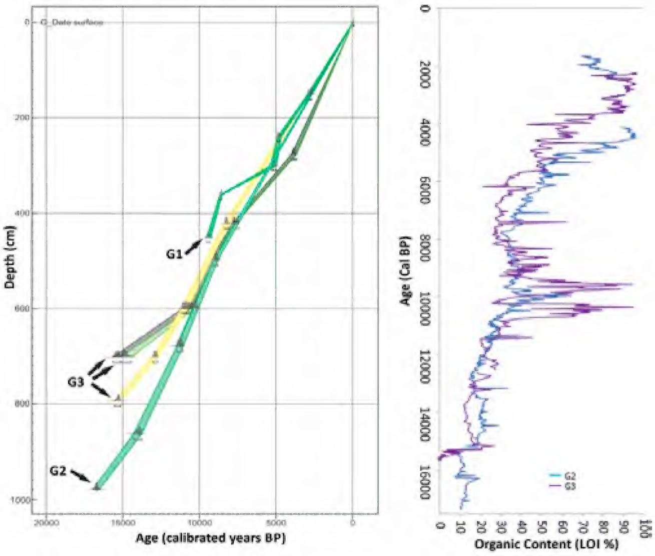

Figure 1. The results of the radiocarbon (^{14}C) dating of the sediments accumulating in Goochs Crater (left). The panel on the right shows the organic content (from loss-on-ignition) of two of the cores recovered from central locations in Goochs Crater.

What is even less appreciated is how dynamic these communities can be. Keith *et al*. (2010) demonstrated changes in woodland-wetland boundaries over decadal time ranges during the Twentieth Century associated with climatic (moisture) variability. The response of THPSS communities to bushfires provides another good example of the dynamics of species and community composition.

This dynamic and resilient response to disturbance has been particularly apparent at Goochs Crater at 960m asl, which has been a major focus of our THPSSRP research. In 2013 Goochs Crater experienced flooding and a major fire (Figure 2) but 'bounced back' quickly from both events. The disastrous fires of October 2013 in the Blue Mountains attracted international interest not least because they were anomalously early in the fire season. We visited Goochs Crater 6 weeks after these fires (December 2013) and found that although many plants were vigorously resprouting from epicormic buds it was still a largely scorched and hostile environment. In contrast, the mire in Goochs Crater was a brilliant green as the surface vegetation rapidly recovered. We can only speculate on the importance of such an oasis to the surviving animals of the vicinity but suspect it must be an important refuge during these lean, post-fire times. As shown in Figure 1 we have recovered and analysed a series of sediment cores from Goochs Crater, the deepest of which extends to 9.85m, representing almost 17,000 years.

As a second example of the diversity of mires in the Sydney Bioregion, we also took advantage of the denuded (post-fire) vegetation in late 2013 to explore an unnamed swamp (subsequently christened Karina Swamp) at 820m asl. Located in the Wollemi Wilderness, access to Karina Swamp involved a circuitous (~18km on foot) route along ridgelines to avoid adjacent deep valleys and canyons in the incised landscape. The mire was relatively narrow and ran adjacent to a rocky wall on the eastern side (Figure 4), a characteristic that attracted us in the search for longer (older) sedimentary sequences.

After probing the entire wet area of Karina Swamp we recovered a 275 cm sediment core from the downstream end of the system where the gradient decreased and the sediments became deeper, much more organic and with fewer sandy layers. We were also surprised to find, in the middle-lower section of the swamp, a series of peat ridges (strings) and water-filled hollows (flarks)

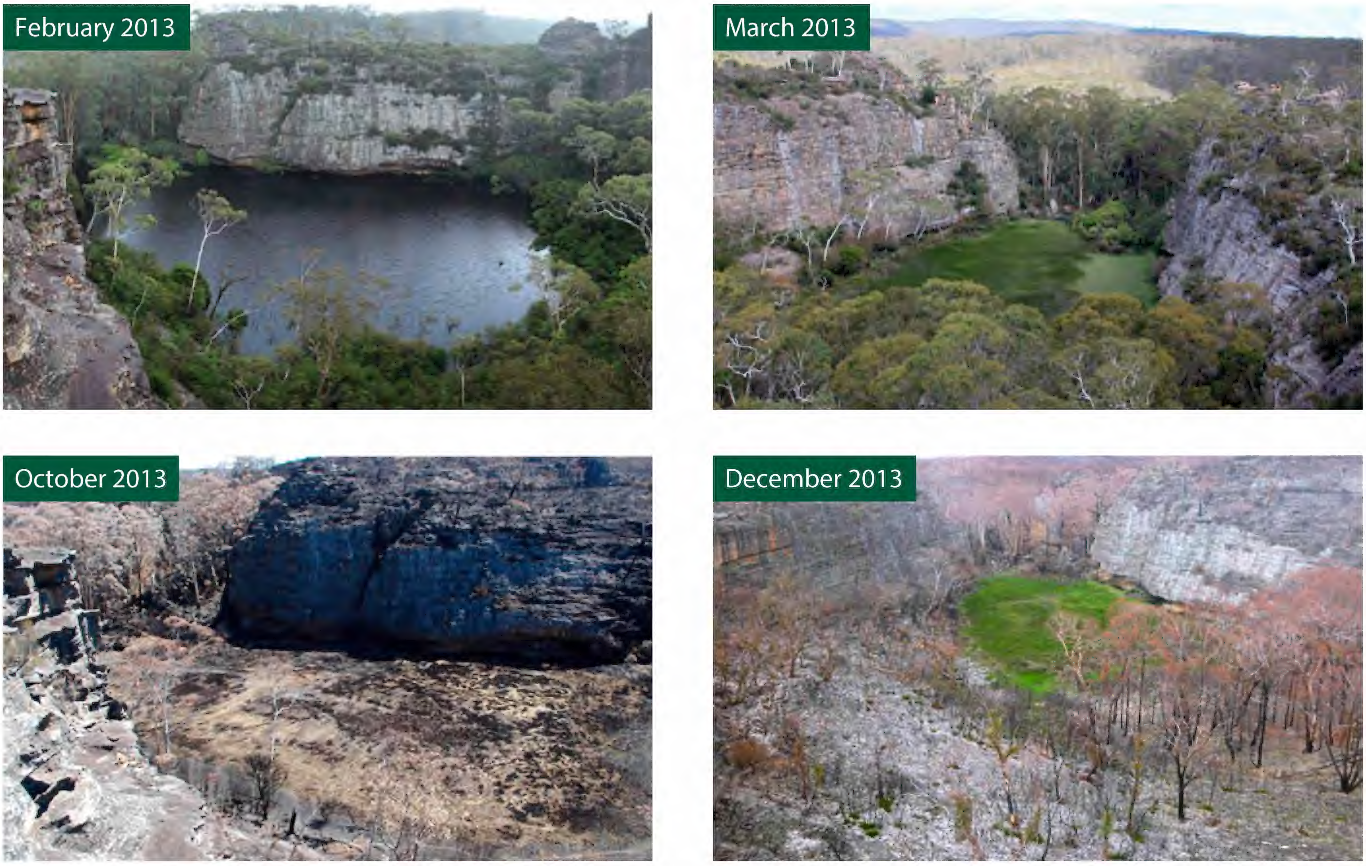

Figure 2. A year in the life of a mire in the Sydney Basin Bioregion: Goochs Crater during 2013. Top left: With at least 1.5 m standing water in February. Top right: A more typical view, with vegetation hiding standing water of ~50cm in March. Bottom Left: The entire swamp surface and surrounds burnt in the October bushfires. Bottom right: by December the swamp surface was an oasis of green in an otherwise burnt landscape. February photo: Albert Chetcuti, October photo: Roger Lembit. March and December photos: Len Martin.

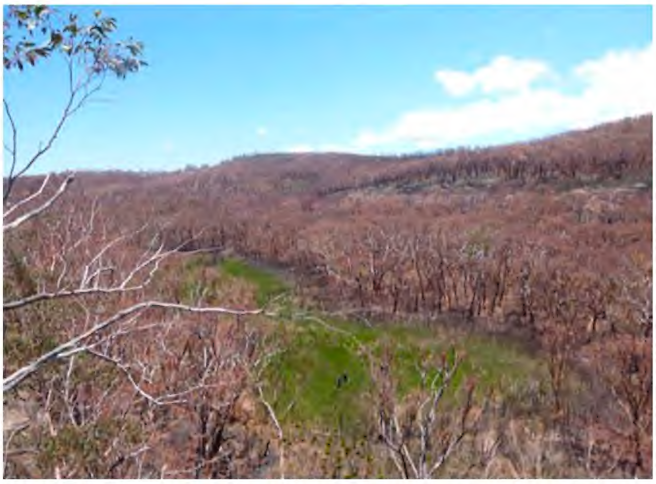

Figure 3. An elevated view of Karina Swamp, looking SSW, showing the abrupt transition between the rapidly regenerating swamp and the surrounding, drier vegetation, with two people for scale in the centre of the image. Photo: Natalie Brennan.

(Figure 4), arranged perpendicular to the slope/flow of the water. At Karina Swamp the strings were up to 15 cm above the water line and the flarks were water-filled and about an equivalent depth, making the entire structures relatively large.

Such 'patterned mires' are more often associated with higher latitude, ombrotropic bogs (Charman 1994; Couwenberg and Joosten 2005; Swanson and Grigal 1988). The closest we have come across in Australia are the Ramsar-listed fen complexes on Fraser Island (and nearby Cooloola), which are the only known subtropical examples in the world (UNESCO 2013; Fairfax *et al*. 2011). To our knowledge such patterning has not been documented on the Australian mainland before and, given its temperate climate, could represent aglobally unique environment.

Roger Good's involvement (SM)

The THPSSRP was established with a Scientific Committee, which was chaired by Roger Good until his untimely death in 2015. It is pretty rare that you get to meet one of your (scientific) heroes: as a young(er) researcher I came across a MSc thesis (Good, 1982) on the effects of prescribed burning in Kosciusko National Park. This thesis was destined to be thrown out, a casualty of departmental restructure, lack of space and the ill-founded view that everything good is published and online. Roger's MSc thesis, which would easily meet the standard of a modern PhD (or two), was incredibly influential in developing my own thinking about fire. As an example, it was the first time I had to give serious consideration to the idea that fire-mediated changes in vegetation might increase the flammability of a landscape (perhaps now familiar as a 'fire cycle') and that regular low intensity fire might have little effect on fuel loads and hence the potential for a wild fire (again recently made more popular as 'fire leverage').

When I finally met Roger in 2012 as a part of the THPSSRP I was further enamoured by his quiet but forceful presence, and as I learned of his more than 50 years of restoration projects in the Snowy Mountains my opinion only grew. (The January 2016 edition of *Ecological Restoration and Management* at doi: 10.1111/emr.12203 provides more details of Roger's career.) Roger was pivotal to the success of the THPSSRP and I am extremely grateful to have known him: he is already sorely missed.

Acknowledgments

Albert Chetcuti and Roger Lembit kindly contributed photos of Goochs Crater. Karina Judd, Tyler King and Natalie Brennan provided assistance in the field. Aspects of this work have benefited from discussion with Martin Krogh, Doug Benson, Sarsha Gorissen, Geoff Hope, Roger Good and Jennie Whinam. This work was supported by a grant from the ANU/Temperate Highland Peat Swamps on Sandstone Research Program Joint Venture. Funding for the AMS ^{14}C dating of the Goochs Crater sediments was made possible by the 2014 and 2015 AINSE Research Award (ALNGRA14019 and 15019) to SM.

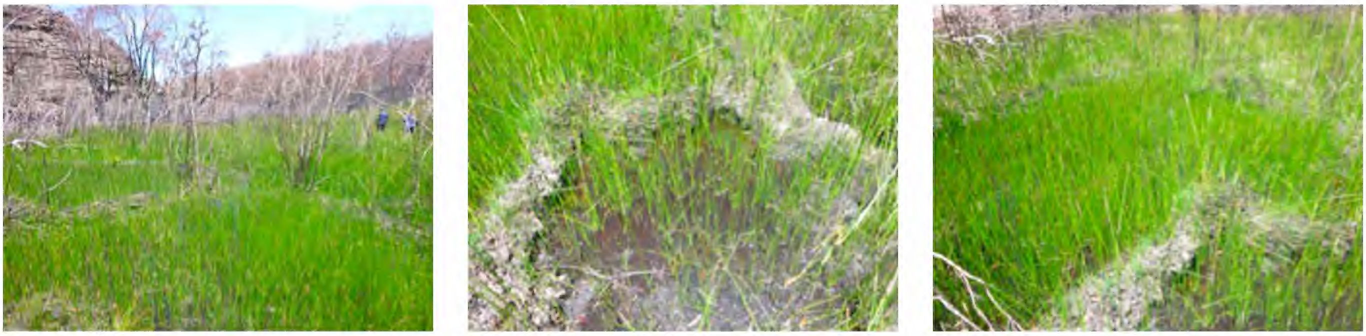

Figure 4. The strings (ridges) and flarks (water-filled hollows) seen on the surface of Karina Swamp after the October 2013 bushfires which impacted the Blue Mountains and Wollemi Wilderness. Photos: Karina Judd and Scott Mooney.

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The benefits of restored linear vegetation corridors for biodiversity conservation – a case study

Re-printed from APC 19(2) September – November 2010

STUART JOHNSTON[1] AND ROGER GOOD[2]

[1]Corporate Environmental Manager, Transgrid.

[2]Research Associate, Australian National Botanic Gardens, Canberra. Email: rgo03227@bigpond.net.au

Linear corridors of native vegetation are significant links between larger remnant areas of native vegetation, in terms of biodiversity conservation and movement of native fauna across the landscape. This is particularly important in regions where extensive decline or clearing of native woodlands for agriculture and other agricultural industries has occurred, e.g. the western slopes of New South Wales (NSW). Unfortunately in many regions the decline or loss of native vegetation linkages has contributed to larger remnant patches of native vegetation being 'islands' in a landscape of cleared agricultural lands. In these regions the restoration and re-establishment of the vegetation linkages can be readily achieved by replanting of trees and shrubs together with the natural regeneration of native species.

In areas of extensive native woodlands and forests, infrastructure and service easements such as powerlines have also resulted in fragmentation of the vegetation and restricted the range and distribution of some native animals that are reliant upon large areas of woodland

and forest. The maintenance of powerline easements has generally involved regular slashing and chemical spraying to suppress regrowth of the native vegetation, but over the past decade more ecologically based techniques have been applied to maintenance and restoration work programs.

The TransGrid experience

In 2001 TransGrid – the owner, operator and manager of some 12 500 km of high voltage transmission lines in NSW – undertook maintenance works over some 70 km of transmission lines in Kosciuszko and Namadgi national parks, resulting in clearing of all native vegetation and a mineral earth swathe through them (Johnston and Good 2004).

Restoration of this bare earth corridor was commenced in May 2001, but only after consideration of the ecological challenges to restoration that the cleared powerline easements presented. The restoration program was completed in September 2003. After an extensive area of restoration works was burnt in the January 2003 bushfires, further works were undertaken between April and November of that year.

Restoration objectives

The objectives of the restoration works were not simply to replace the topsoil and to revegetate the denuded areas, but to establish a range of native shrubland and herbaceous species habitats, through the reshaping of easement lands and the replanting of local native shrubs and grasses. This was achieved through the planting of many hundreds of thousands of tubestock of species from the local area (mostly leguminous species of *Acacia*, *Daviesia, Hovea, Oxylobium* and *Pultenaea*) and the sowing of all the easements with native grasses and groundcover plants. A good cover of native grasses was achieved within three years while a mosaic of native shrub patches took several more years, particularly those regenerating shrub areas impacted by the 2003 bushfires.

Dense shrub plantings

Specific plantings of shrubs in dense clusters were made at and along the 'ecotone' between the open easement vegetation and the forest and woodlands through which the easements pass. This was done in recognition of the plant species diversity that occurs in these areas in the natural state, and their significance for many native fauna and avifauna species.

The planting of mainly leguminous shrub species in these clusters was done on the basis of their ease of seed collection and propagation, their growth rates and the range of structural habitats and food range they provide, as well as their ease of maintenance through ecologically based burning, slashing and mulching.

The patches of dense shrub were established to provide habitat for small birds crossing the powerline easements and for birds that would utilise the easements as local or regional flyways. As the easements traverse undulating to steep terrain and occur over a large altitudinal range, the shrubland patches also provide transient refuge and feeding habitat along the easements for birds and several small mammals that occur at or within specific elevation ranges.

Monitoring

Following the completion of the restoration and revegetation program in 2004 a semi-permanent monitoring program was established. This aimed to assess the stability and sustainability of the restoration works, the trends and condition of the planted and natural vegetation regeneration, and the use of the restored native vegetation by birds and animals. The monitoring sites have been maintained to the present time.

As was expected, the open native grassland that was created was attractive to kangaroos, wallabies and wombats, which placed considerable grazing pressure over several years on the rate of regeneration of the planted shrub material. As the shrubs gained height,

***Acacia rubida* (top) and *Hovea rosmarinifolia* (bottom), two species used in TransGrid restoration plantings. Photos: Murray Fagg.**

size and density, the numbers of bird species utilising the grassy shrubland patches increased, from two or three to 31 where the movement of birds both across and along the easements was occurring.

Also of interest is that the number of bird species utilising the easement as a 'flyway' exceeded the number of species recorded for the adjacent and extensive forests and woodlands through which the easements occurred. This may possibly be a result of the ease of observation along the easements, but also as a response to the additional habitats provided for many of the smaller bird species, particularly at the edges of the easements.

Discussion

The restoration and revegetation of linear corridors linking larger areas of remnant native vegetation in cleared landscapes is now well recognised and increasingly is being carried out. Less well recognised and implemented is the restoration of linear infrastructure easements that dissect and fragment large areas of natural vegetation, particularly powerline easements where maintenance in the past has been one of vegetation suppression and removal.

The 'maintenance disaster' that occurred in the Snowy and Brindabella mountains in south-east NSW and the Australian Capital Territory in 2001 resulted in a complete review of the TransGrid easement maintenance programs. This lead to an emphasis on ecological understanding and the ecological principles of rehabilitation, revegetation and restoration as the basis for any future powerline maintenance programs. Where this approach has been taken, it has resulted in improved biodiversity on the easements, as well as contributing to the movement and distribution of native plants and animals across the regional landscape.

The monitoring program has identified a continuing increase in fauna and avifauna use of the easements since the restoration works were carried out, to the extent that observed native bird numbers using the easements exceed those recorded for the adjoining forests and woodlands. This increasing use is focussed on the ecotone area and the diverse clusters of shrub patches planted as part of the restoration program.

This new approach to maintenance by TransGrid has also lead to the company's support of the 'corridors of green' program on rural lands, such that remnant native vegetation is linked with other remnant vegetation on neighbouring rural properties. It has also focussed much research and field trials of plant species suitable for restoration programs, particularly in sensitive areas such as conservation land and habitat of threatened species and ecological communities.

Conclusion

The restoration of cleared linear corridors that traverse and fragment larger areas of native vegetation (including reserves) can contribute greatly to biodiversity conservation and the movement of native biota. Restoration of a severely damaged or denuded linear corridor, as experienced with the TransGrid powerline easements in Kosciuszko National Park and Namadgi National Park, also provides an opportunity to recreate habitats for specific flora and fauna species that may be under threat or of restricted distribution.

Cleared easements should therefore not be considered as always being detrimental to ecosystem or species decline. Restoration to near-natural corridors can have real benefits to biodiversity conservation, and contribute to individual species survival if the restoration works are planned and implemented on ecological principles and practices.

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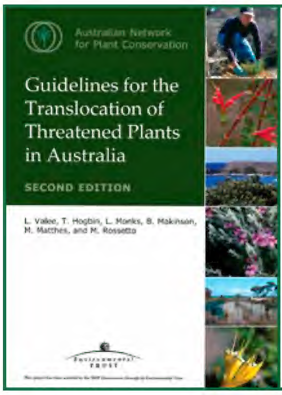
Australian Network for Plant Conservation
Guidelines for the Translocation of Threatened Plants in Australia
SECOND EDITION
L. Vallee, T. Hogbin, L. Monks, B. Makinson, M. Matthes, and M. Rossetto

Guidelines for the Translocation of Threatened Plants in Australia

The deliberate transfer of plants or regenerative plant material from one place to another (eg re-introduction, introduction, re-stocking).

Second Edition 2004 | L. Vallee,T. Hogbin, L. Monks, B. Makinson, M. Matthes and M. Rossetto
Australian Network for Plant Conservation, Canberra.

For more information and to order, go to http://www.anpc.asn.au/translocation

Management of herbivory in the Montane Heath and Thicket TEC of the eastern Stirling Range, Western Australia

SARAH BARRETT AND DAMIEN RATHBONE

Department of Parks and Wildlife. Western Australia. Email: sarah.barrett@dpaw.wa.gov.au and damien.rathbone@dpaw.wa.gov.au

Introduction

The Montane Heath and Thicket of the eastern Stirling Range, Western Australia, is an EPBC Act-listed threatened ecological community (TEC), ranked critically endangered due to the extent and severity of *Phytophthora* dieback (Barrett 2000). It contains a number of species endemic to the community as well as 11 Threatened flora species. Less than 14 % of the community retains a representation of the original suite of plant species that were once common and many dieback-susceptible species have become locally extinct (Keith *et al*. 2014). During the past 50 years, fire frequency has also increased and 74% of the ecosystem has experienced a nine-year fire interval as a result of extensive fires in 1991 and 2000 (Barrett and Yates 2014) Much of the TEC, including its threatened species, is comprised of obligate re-seeders with many very slow to mature in this montane environment. Fire, in conjunction with *Phytophthora* dieback (Moore *et al*. 2015), has led to severe population declines, particularly after the 2000 fire. Climate change also threatens these mountain-top species that have literally nowhere to migrate to in response to a warming climate.

Herbivory

Monitoring of critically endangered species such as Mountain Banksia (*Banksia montana*), Yellow Mountain Bell (*Darwinia collina*) and Stirling Range Beard Heath (*Leucopogon gnaphalioides*) after the 2000 fire, indicated that browsing by rabbit (*Oryctolagus cuniculus*) and / or quokka (*Setonix brachyurus*) was having a significant impact. Repeated browsing of growing tips were prevented the growth necessary to enable flowering and set seed to occur and placed the regenerative potential of these species at risk. Initially, it was hoped that herbivore numbers would eventually decline allowing plants to 'escape' this intense browsing pressure. Unfortunately, by the late 2000s it was evident that browsing impacts remained high and herbivory posed a considerable threat to the conservation of the TEC despite other conservation measures such as application of phosphite to manage *Phytophthora* dieback.

Recovery Actions

Initial recovery actions included the targeted eradication of rabbits using 1080 oats and the establishment of protective exclosures for highly threatened flora species. Small individual exclosures were initially built for species such as the Mountain Banksia, Stirling Range Beard Heath and Mountain Latrobea (*Latrobea colophona*). Monitoring confirmed the significant impact of browsing across these populations and revealed that the small exclosures were highly effective at protecting individual plants.

In 2013, the positive results of small-scale fencing motivated the expansion of browsing mitigation through the construction of larger fenced areas. A project was developed and funding sourced from State Natural Resource Management with the aim of protecting focal patches of threatened flora as well as the more common species that make up the TEC.

Materials were transported by helicopter to selected sites at about 1000m above sea level. In 2014, eight 25 x 25m fenced areas were constructed on Bluff Knoll and in 2015 another two exclosures were built on nearby mountain tops (Fig.1).

Detailed monitoring was established to compare growth within and outside the fenced areas and within months the positive effects of fencing were evident. At the same time, remote infra-red photography was used to ascertain exactly which herbivores had the greatest impact. Footage in 2011 had captured quokka and rabbits on camera with quokka photographed 'in the act' of browsing the threatened Stirling Range Beard Heath. New photography in 2014 and 2015 again revealed that quokka was the major herbivore affecting three threatened flora (Giant Andersonia (*Andersonia axilliflora*), Stirling Range Beard Heath, Mountain Latrobea) (Fig 2). An analysis of camera footage from 2014–15 revealed that of the five fauna species recorded, 85 per cent of events were due to quokkas, the only strictly herbivorous species. Other species observed were mardo (*Antechinus flavipes*), bush rat (*Rattus fuscipes*), quenda (*Isoodon obesulus*), feral cat (*Felis catus*) and more recently dunnart (*Sminthopsis griseoventor*) and honey possum (*Tarsipes rostratus*).

In 2015, analysis of the plant fragments in the scats of quokka and rabbits revealed that monocot (sedges and grasses) species formed the major component of rabbit diet in this plant community. In contrast, quokka scats contained a wider variety of dicot species, in particular species from the families Myrtaceae and Ericaceae.

Fragments were identified from two threatened species (Yellow Mountain Bell, Stirling Range Beard Heath) as well as another two conservation-listed species in the Ericaceae.

In 2015, monitoring confirmed the positive effect of fencing with significant increases in plant volume and the number of flowers for fenced individuals of Yellow Mountain Bell, Stirling Range Beard Heath and Mountain Latrobea, compared with those outside the exclosures (Fig.3, Fig. 4). The first significant collection of seed from fenced Mountain Latrobea was made in 2015; a species once close to local extinction.

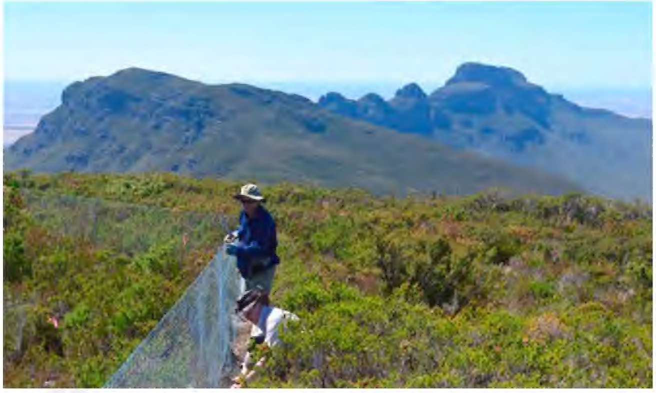

Figure 1. Herbivore exclosure near Bluff Knoll, Stirling Range National Park.

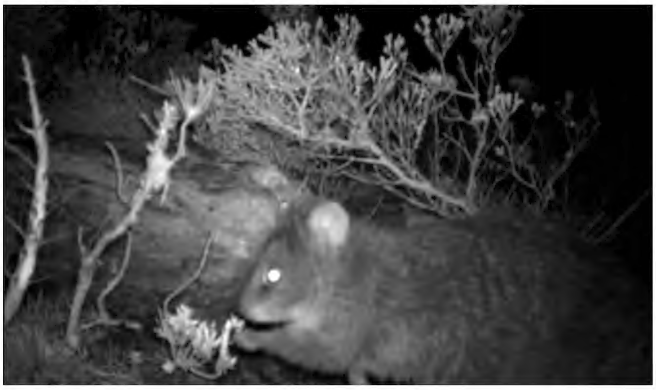

Figure 2. Quokka browsing on Stirling Range Beard Heath.

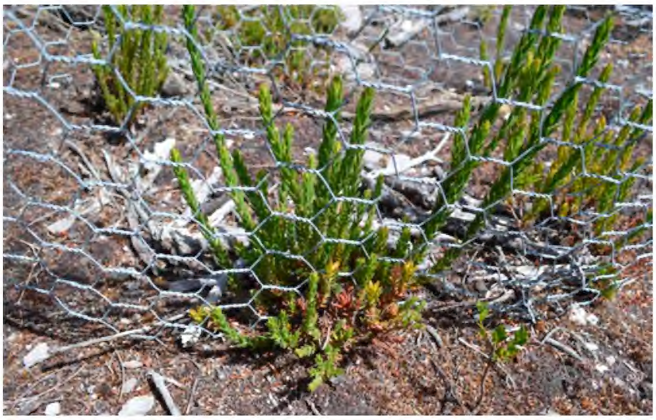

Figure 3. Stirling Range Beard Heath heavily grazed outside fence; significant recovery inside fenced exclosure.

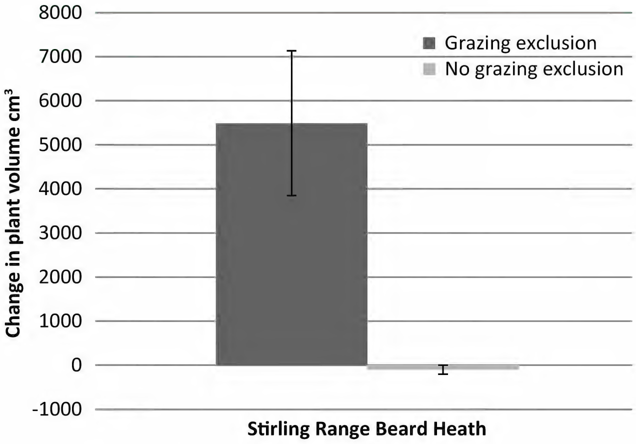

Figure 4. Mean (SE) change in plant volume for tagged individuals of Stirling Range Beard Heath) 18 months after grazing exclusion (dark grey bar) and no grazing exclusion (light grey bar).

Conclusions

Browsing impacts due to native herbivores suggests disequilibria within the normal ecosystem processes as a result of multiple interacting threats. The results of this project so far indicate that rapid recovery has occurred within the exclosures. Many threatened species are already flowering and producing seed that will replenish soil seed banks. Browsing mitigation will also complement the investment made into other conservation activities in the montane TEC, such as the collection and preservation of seed in Parks and Wildlife's Threatened Flora Seed Centre, translocations, the re-stocking of keystone montane species and the aerial application of the fungicide phosphite to tackle *Phytophthora* dieback. If a bushfire should occur at some time in the future, both threatened and more common members of the TEC species should now be better able to regenerate and persist in this unique mountain community.

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Can synthetic vegetation (novel ecosystems) help nature conservation in the Anthropocene?

PETER BRIDGEWATER

Centre for Museums and Heritage The Australian National University. Email: peter.bridgewater@anu.edu.au

In Bridgewater (1988) I published on the topic of synthetic vegetation, which I described as "admixtures of native, naturalised and exotic species". Further, I suggested these may be transitional phases in the degradation of a native plant community, or metastable communities capable of persistence, given appropriate management. It's fair to say this idea was greeted with some scepticism, both in terms of the name and the possibility that there may be positives associated with such mixtures.

Coastal vegetation in Australia is one example of synthetic vegetation which may help clarify the idea. Strandline vegetation in southern Australia was absent pre-European colonisation. Now, however, the cosmopolitan and introduced species *Cakile maritma* with the introduced South African *Arctotheca populifolia* frequently form a strandline community, sometimes with the native *Spinifex sericeus* as a component, if the substrate is particularly sandy. This simple community may well help in buffering the effects of coastal changes arising from sea level and other climatic changes. Native grass-dominated salt marsh from New South Wales to southern Western Australia frequently has an introduced species as a component – *Parapholis incurva*. It is a naturally occurring grass of saline meadows in western and Mediterranean Europe, but is introduced in Australia. It appears as an additional species to the native assemblage, with no apparent threat to vegetation stability.

I wrote further on the topic in Bridgewater (1990), with the idea maturing and transforming into the novel ecosystem concept (Bridgewater *et al*. 2011; Hobbs *et al*. 2013; 2014). Hobbs *et al*. (2014) illustrate the spectrum between historical, hybrid and novel ecosystems. They use historical in lieu of natural, which I think is a preferable term. Figure 1 shows a decision tree adapted and simplified from their publication. This decision tree can help plan approaches to managing historical and novel ecosystems, as well as hybrids between them that may have potential for restoration. Hybrid ecosystems are less stable than either historical or novel systems, but may play a role in rapidly changing landscapes. As for novel ecosystems there are two chief management objectives that can be aimed for: biodiversity conservation, and ecosystem service provision. Of course these are not mutually exclusive, but often the choice is dictated by social and community needs and desires.

Novel ecosystems are also controversial but as the Ecological Society of America annual meeting in 2016 has the title "Novel Ecosystems in the Anthropocene", it's now becoming mainstream. The Anthropocene is the important term here. There is broad agreement that we are now living in the Anthropocene with the main characteristic being rapid, often unpredictable, change. There are arguments about when the Anthropocene began, but human geographic expansion from the late Pleistocene began a cascade of changes in the biosphere, reinforced by continuous technological development. Such changes are a consequence of activities including hunting, global movement of plants and animals, and landscape burning and deforestation.

The arguments for climate change as a key driver for ecosystem and landscape change are familiar and well-rehearsed. But there are a wider range of environmental parameters causing change in the Anthropocene – including biodiversity loss, nitrogen pollution and global freshwater overuse. Alongside climate change the rate of biodiversity loss is often cited as a key feature of the Anthropocene. Interference with the nitrogen cycle is another, largely unseen but insidious change. But loss of biodiversity should be seen as part of an overall set of global biodiversity changes, and linked closely to changing climate, nitrification and reduction in available freshwater – and other consequences linked to those changes. The recent wildfires in Tasmania are a classic fallout consequence of these interacting factors (see Bowman, 2016). Under that scenario it would seem all is lost, but the reality is we simply don't know.

So can synthetic vegetation/novel ecosystems support nature conservation? Understanding synthetic or novel ecosystems, typically identified by vegetational change, can certainly help with fauna conservation. Hobbs *et al*. (2013) have a range of examples, including from the Galapagos, Hawai'i and the Everglades World Heritage areas. Additionally, novel vegetation can result in novel faunal assemblages– a good example is provided by Lindenmeyer *et al*., (2008). These novel assemblages can help with faunal species conservation by increasing available habitat and extending ranges – both useful attributes in a time of increasing global change.

Barrett *et al*. (2016) give an interesting example concerning conservation of the invertebrate *Peripatus* in the urban hinterland of Dunedin. They found *Peripatus* positively associated with shaded, moist sites with an abundance of decayed materials, typically with an overstorey including native tree fuchsia (*Fuchsia excorticata*) mixed with other New Zealand natives and introduced species. *Peripatus* persisted in fragments dominated by exotic vegetation and a history of disturbance, including urban gardens and forest plantations – in other words synthetic vegetation. Barret *et al*. (2015) suggest it is important to study habitat use at multiple scales within urban areas for biodiversity conservation, even for relatively sessile invertebrates such as *Peripatus*. They also show *Peripatus* populations can thrive in landscapes traditionally discounted as being inhospitable due to disturbance.

So, what can synthetic vegetation do for *plant* conservation, and what are the dangers of using synthetic vegetation as a conservation intervention? There is much less written on this, possibly because it has always seemed easier to accommodate native fauna with introduced plants, rather than see native plants co-habiting easily with introduced plants. Yet the *Peripatus* example suggests synthetic vegetation has the potential to offer possibilities for native plant conservation. There are examples of species, and even species combinations rare in one country thriving as part of synthetic vegetation. Bowman (2016) suggests relocation of threatened Tasmanian plant communities from fire-prone regions to sub-Antarctic islands. There undoubtedly synthetic vegetation would arise. But this blurring of *ex-situ* and *in-situ* approaches is how plant conservation practitioners have to see the future.

So, finally, it would be good to hear of such examples, especially where management and manipulation of synthetic vegetation has had, or seems to have potential for, native plant conservation. As the saying goes, *The future ain't what it used to be*. But we can mould it to something closer to one that is sustainable and diverse. I would be interested in any feedback from this article, particularly if there are cases of successfully using synthetic vegetation as part of a plant conservation exercise.

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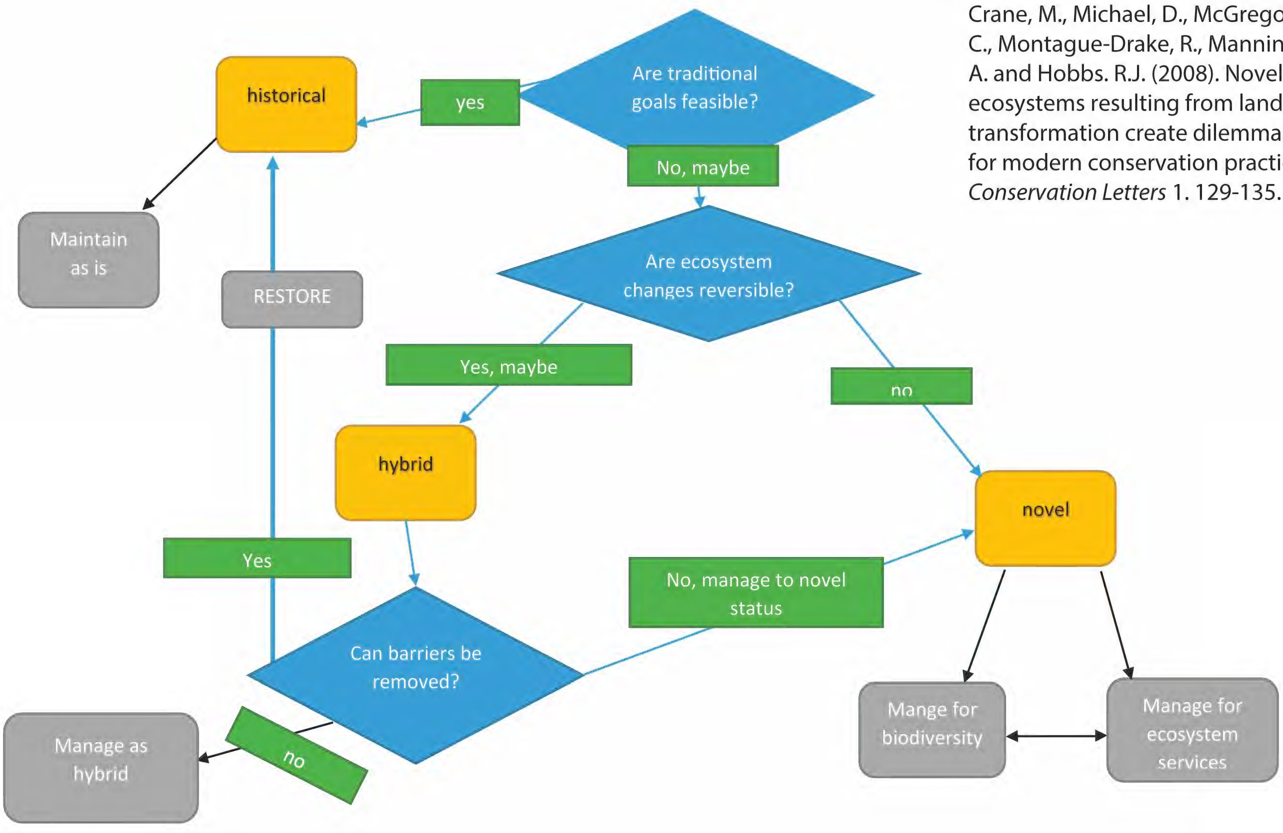


Decision Tree for management of novel ecosystems (after Hobbs *et al.*, 2014)

News from the Australian Seedbank Partnership

Hanging out with King Billy: Seed Collecting in Tasmania's Highlands

JAMES A. WOOD[1] AND TIM RUDMAN[2]

[1]Royal Tasmanian Botanical Gardens, [2]Natural Values Conservation Branch of Department of Primary Industries, Parks, Water & the Environment. Email: james.wood@rtbg.tas.gov.au

Seed Conservation in the Highlands

Seed conservation has become a growing part of native plant conservation within Australia. The ability to safeguard the genetic diversity of multiple provenances of both threatened and common species for relatively low cost has made it a valued addition to the arsenal of tools combating biodiversity loss.

Actually securing seed collections however can be challenging, particularly for species restricted to remote areas. Long-term storage of material tends to require harvesting at peak maturity which typically occurs at the point of dispersal. For species where dispersal can be a fleeting part of a plant's yearly cycle, it can be difficult to capitalise on windows of opportunity. For species occupying remote peaks the challenge is made even more difficult with large number of people-hours required to a) identify a population that is fruiting well, b) monitor to determine when the seeds are likely to be ripe and c) finally harvest the material. As can be appreciated collecting alpine species is frequently not easy as it relies on the weather working with you and with the rest of your collecting schedule.

The Tasmanian Seed Conservation Centre (TSCC) at the Royal Tasmanian Botanical Gardens (RTBG) was established almost ten years ago to provide a repository of seed sufficient to conserve the genetic identity of native species and support research and conservation action. In 2013 the Gardens secured federal funding to collect seed of alpine species and the native montane conifers. The funding supported a collector to coordinate the program. It also allowed the use of helicopters to survey and collect on numerous peaks and mountain ranges, in addition to the more typical ground based collecting trips.

The program went extremely well. Fifty collections were made of 42 species mostly restricted to higher altitudes within Tasmania. However in that year none of the five montane conifer species could be found with adequate cone production that would warrant action. Two populations of Strawberry Pine were identified to have developing seeds but these did not ripen until the following year, at which point they were collected.

Tasmania is home to ten species of native conifer, seven of which are endemic to the state. Of these seven

RTBG volunteer Alan Pegg collecting *Athrotaxis selaginoides* (king billy pine) from Pigsty Ponds at the southern end of Moonlight Ridge, Tasmania.

species, five are restricted to the Tasmanian highlands and have their stronghold in the Tasmanian Wilderness World Heritage Area. Two of these are trees, King Billy pine (*Athrotaxis selaginoides*) and Pencil pine (*Athrotaxis cupressoides*), that live to extreme age (1000 + years) and are primitive relictual species from past cool climates. Three shrubs, Cheshunt (*Diselma archeri*), Strawberry (*Microcachrys tetragona*) and Drooping (*Pherosphaera hookeriana*) pine, probably also achieving considerable age with similar links to past cool climates. It is considered likely that these conifers are particularly vulnerable to increasing drought and fire risk due to climate change. In particular some populations have already been lost to fire and may not be able to re-establish naturally due to fragmented distributions, poor dispersal capacity, grazing pressure and soil loss.

At the start of 2015 seed collections for highland conifers at the TSCC remained inadequate due to the periodic seed bearing behaviour of many of these pines (see table 1). Cones and seed for at least 3 of the species are produced on mass only once every 6-7 years, severely limiting opportunities for collection. The autumn of 2015 saw four of our alpine conifers experience a major seeding (termed a “masting” event) across a broad sweep of Tasmania’s western mountains. This event provided a rare opportunity to make large high quality seed collections for the RTBGs’ seed conservation program. A collaborative project was established between the Tasmanian Wilderness World Heritage Area program in the Natural Values Conservation Branch of DPIPWE and the RTBG to undertake the collection with assistance from the Tasmanian Land Conservancy and RTBG volunteers.

Worth the effort?

The concerted effort made in 2015 yielded a large number of high quality collections, with quantities that lend themselves to substantial conservation work and research in both the short and long term (the average collection size for these four species now stands at 50,000 seeds). The outcomes would seem to justify capitalising on this major masting event. The environmental cues leading to masting events in Tasmania’s montane conifers are currently unknown. Research conducted outside Tasmania has revealed a high correlation of masting events with weather conditions prevailing over the previous two summers. If Tasmania’s conifers follow a similar pattern of behaviour then it might be possible to predict future events with a year’s notice, permitting greater preparation and possible seeking of funding to support future efforts. Fortunately for 2015 the seedbank had reserve funds accrued over the last nine years from previous project savings. This permitted the option to once again hire helicopters to access remote sites and fully capitalise on the windfall that this masting event presented.

At the time of writing (late January 2016) several fires have taken hold in Tasmania’s highlands, including at least one site that was collected from in 2015. It appears the stand of conifers we sampled from has remained unharmed, however nearby stands have been lost or damaged in the fire. This underlines the importance of taking action when opportunities present themselves. As the impacts of climate change continue we may not get a second chance.

For the full report on the 2015 conifer project a pdf copy can be found on the Tasmanian Regions website – https://www.tasmanianregions.tas.gov.au/regions/wp-content/uploads/sites/3/2015/08/Alpine-Conifer-Project-2015-Report.pdf

More images from the project can be seen on the RTBG Flickr site – https://www.flickr.com/photos/rtbg/sets/72157649520203013/

RTBG staff and volunteers combining fruit of *Athrotaxis selaginoides* (king billy pine) collected at Moores Bridge, Moonlight Ridge, Tasmania.

Table 1. Seedbank collections pre and post 2015.

Taxa	**Total Seedbank Collections**		**Largest Collection (Viable Seed)**		**Total Viable Seed**	
	Pre 2015	**2015**	**Pre 2015**	**2015**	**Pre 2015**	**2015**
Athrotaxis cupressoides	4	12	36,000	137,500	71,600	658,400
Athrotaxis selaginoides	1	8	11,000	72,200	11,000	293,700
Diselma archeri	1	8	3,700	270,400	3,700	472,600
Pherosphaera hookeriana	1	5	3,500	117,200	3,500	229,500
Total	7	33		**Total viable seed**	89,800	1,654,200
				Average collection size	12,829	50,127

ANPC Member Profile

Melissa Millar (ANPC Secretary)

What is your current position?

I am a Research Scientist with the Science Division of the Western Australian Department of Parks and Wildlife (DPAW). I have been with the Department since 2008. My work involves utilising molecular genetic techniques for the circumscription (defining taxa), conservation, restoration and management of Western Australian flora. I work on a variety of projects ranging from examining the effects of recent and potential anthropogenic processes, such as habitat fragmentation and reduction in population size, on population genetic diversity and structure, determining mating systems and patterns of gene flow, examining patterns of phylogeographic structure, providing guidelines for provenancing and seed collection, and assessing the genetic success of restoration programs.

Melissa Millar

What are you working on at the moment?

My current work is mainly focused on delivering the Australian Research Council funded Linkage Project 'Is Restoration Working? An Ecological Assessment.' This project is a collaboration between the Western Australia Department of Parks and Wildlife, The University of Western Australia, the Western Australian Botanic Gardens and Parks Authority, and Gondwana Link Ltd.

It's exciting to be working on the largest environmental restoration project ever tackled in Australia. The ambitious conservation and restoration initiative undertaken by Gondwana Link Ltd aims to provide habitat connectivity and integrated ecosystem function at a regional scale by restoring native vegetation across the south west of Western Australia, from the wet forests in the west to the dry woodland systems bordering the Nullarbor Plain to the east. Significant progress has already been made in this. Recent focus has been on the Fitzgerald River-Stirling Range region, a 70 km section of fragmented mallee and woodland remnant vegetation located between the Fitzgerald River National Park and the Stirling Ranges National Park. This is an area of exceptional plant species richness and endemism. Clearing of native vegetation has occurred relatively recently in this area and, although vegetation loss has been significant, the impacts of fragmentation on remnant vegetation remain mild and diversity within remnants is high. A number of ex agricultural properties in the region have been restored with seed from nearby remnants and with different restoration regimes. These properties are now valuable experimental sites at which to assess the success of state of the art restoration activities, in terms of both ecological and genetic viability.

Recently there has been greater recognition in the field of restoration ecology that the most ecologically and genetically viable restored populations will be those where reproductive outputs, plant pollinator interactions, genetic diversity, mating systems and patterns of pollen dispersal most closely mimic those found in natural or undisturbed remnant vegetation. The work we are conducting with the Gondwana Link project specifically aims to assess the ecological viability (reproductive output and pollinator behaviour) and genetic viability (genetic diversity, mating systems, patterns of pollen mediated gene dispersal) of a range of plant species at established Gondwana Link restoration sites in the Fitzgerald River-Stirling Range region and compare these processes with those maintained in nearby undisturbed natural vegetation. I think the great strength of this project is that it addresses the issue of poorly defined success criteria and lack of long term monitoring in many restoration projects and recognises the need to move measures of restoration success beyond that of population establishment and survival. By focussing on evaluating evolutionary processes we can get an idea of how successful restored populations may be in adapting to changing environments, persisting in both the short and long term, and functionally integrating into the broader landscape. Hopefully the results of the work will contribute to improved adaptive management outcomes at these and other sites both in the Gondwana Link network and elsewhere.

How did you end up working in plant conservation?

The first time I did plant tissue culture, completing a Science degree in Biotechnology, I knew I wanted to work somewhere in this field. I did my Honours year with Jen McComb, Margaret Byrne and David Coates at what was then the Western Australian Department of Conservation and Land Management. The work involved designing a field trial that would allow pollen flow to be tracked into and among Phytophthora resistant clones, and assessing the mating system of Jarrah. I found it hard to believe that until then no one had taken the time to assess this basic aspect of the biology of what is arguably one of our most iconic and valuable tree species. I found the experience and the people I worked with very inspiring. I then worked for a few years in the field of specialised tissue culture (somatic embryogenesis and doubled haploids), but did not find the focus on exotics for advanced breeding in agroforestry and agricultural programs to be rewarding. I returned to further study in molecular genetics research and completed a PhD creating a molecular based diagnostic test for identifying subspecific variants and assessing the mating system and patterns of intra and inter subspecific gene flow in the *Acacia saligna* species complex. Since then I have worked on the conservation of native species.

How long have you been involved with the ANPC?

I attended my first ANPC Annual Conference in Perth 2010. Since then I have attended and presented at several conferences, although I have not previously played a formal role in the Network. I was invited to join the ANPC committee and become the Secretary in early 2016 and am looking forward to becoming more involved with the members of the Network and its work.

News

Australasian Systematic Botany Society Conference 2015 in Canberra

ALEXANDER N. SCHMIDT-LEBUHN

CSIRO, Centre for Australian National Biodiversity Research. Email: alexander.s-l@csiro.au

From 29 November to 3 December 2015 the annual conference of the Australasian Systematic Botany Society (ASBS) took place in Canberra. Organised by the Centre for Australian National Biodiversity Research and with the title "Building Our Botanical Capital", it brought together plant systematists and taxonomists from all over Australia and New Zealand and attracted colleagues from as far as China and the United States.

Systematics and taxonomy are rapidly evolving and many new techniques are helping to unravel complex relationships among the world's plants. While understanding the evolutionary relationships within and among species is the direct aim of systematics, it also provides a critical foundation for conservation management and policy. The Australasian and New Zealand floras are among the most diverse in the world and harbour numerous endemic species about which we still have much to discover. With evolving technology and the wealth of research happening in the region this was an opportune time to come together and discuss recent work.

The main program comprised three days of presentations at the CSIRO Discovery Lecture Theatre, with sessions designed to showcase recent developments in systematics and taxonomy. The session titles were Collections-based Science, Genomic Data in Plant Systematics, Online Keys and Electronic Floras, Assembly and Visualisation of Morphological Data, Species Delimitation, and Phylogenetics. Numerous talks, too many to name here, were directly relevant to plant conservation.

The collections science session started with an eye-opening keynote address from Vicki Funk, examining the past, present and future use of collections to gain new insights into systematics, biogeography, biodiversity and phylogenetic theory. Sarah Mathews examined global hotspots of conifer diversity, many of which are concentrated in East Asia, New Caledonia and New Guinea. Peter Heenan presented endemism hotspots in the New Zealand flora along with an estimate of how well they are covered by existing nature reserves. The geologically young, alpine regions of the South Island are home to many recently evolved endemic lineages (neo-endemics) while the North Island carries many older lineages that are not found elsewhere (palaeo-endemics). The study also resolved some diversity hotspots that are potentially still at risk.

Genomic data are becoming ever more useful to the resolution of many research questions. In his keynote address, Craig Moritz provided an overview of methodologies for integrating numerous technological

Figure 1: From left to right, Darren Crayn, Roslyn Prinsley, Sue Serjeantson, and Mark Tucker discussing the transition from the results of scientific research into policy decisions. Photo: Murray Fagg.

developments to understand how evolutionary responses to past environmental change – adaptation, range shifting and speciation – have shaped the diversity that we see now, with applications to conservation planning and practice. The subsequent genomics talks dealt with topics ranging from cryptic diversity to evolutionary relationships within plant genera and even whole plant communities. They also included a presentation by James Clugston on conservation genomics, specifically establishing a fine scale molecular marker system that allows the exploration of genetic diversity in wild and cultivated cycads.

Correct identification of specimens underlies virtually all scientific studies and every conservation effort, and identification keys are consequently one of the most crucial and useful outputs of taxonomic and systematic research. Today identification aids have moved far beyond individual books published at eighty-year-intervals and are now moving online. Ilse Breitwieser's keynote discussed the various forms of 'floras' that exist, from printed picture field guides to web sites, and the critical questions of what should and shouldn't be included and how. She also discussed the lessons learned and challenges overcome while working in a collaborative online environment during the development of the eFlora of New Zealand. Other talks in the eFlora session covered all scales of Australasian plant biodiversity: The Flora of Australia Online, the state floras of Victoria and South Australia, regional floras, and an updated treatment of the New Zealand tangle ferns.

The species delimitation session in particular covered many topics of conservation significance, as taxonomic re-circumscriptions may lead to reassessment of conservation status. Presentation topics included the diversity of the spider-flower genus *Cleome* (Russell Barrett) and of *Synostemon* (Ian Telford) as well as co-existing ecotypes in south-western Australian sexually deceptive orchids (Ryan Phillips). In the phylogenetics session, Lalita Simpson examined habitat availability for endemic mountain-top plants of tropical Australia under different climate change scenarios.

Post-graduate students of systematics and taxonomy were well represented at the conference, giving impressive presentations of their research and making extremely valuable contributions to the conference program. Benjamin Anderson, University of Western Australia, won the Pauline Ladiges Prize for the best student talk with his presentation on the evolution of *Triodia*, and Charles Foster, University of Sydney, took home the prize for the best student poster for a time-calibrated chloroplast phylogeny of the flowering plants. The winner of the Bob Anderson Memorial Prize, which financially supports students to present at the conference, was Janet Gagul, James Cook University.

The other major category of student prizes is the Australian Conservation Taxonomy Awards. These awards are designed to foster research by young scientists on important taxonomic problems that have significant implications for conservation in Australia. The Nature Conservancy created these awards with generous financial support from The Thomas Foundation. The awards provide $5,000 toward research costs and up to $2,000 to allow attendance at two ASBS conferences. Recipients in 2015 were Rachael Fowler, University of Melbourne, and James Clugston, University of Edinburgh/Royal Botanic Gardens, Sydney. Students interested in the prizes can find more information at http://www.asbs.org.au/asbs/student.html

A diverse calendar of events supplemented the scientific presentations. The pre-conference mixer on 29 November was also the official launch of the Interface art exhibition by local artist Natalie Maras who worked as artist-in-residence at the Australian National Herbarium in 2015 focussing on cryptogams. On Monday 30 November, the evening concluded with a public panel on Effective Transition from Science to Policy. The panel consisted of public servants with experience in implementing a diverse range of policies and scientists who have provided information to support government policy: Darren Crayn, Australian Tropical Herbarium, Roslyn Prinsley, Office of the Chief Scientist, Sue Serjeantson, Australian National University, and Mark Tucker, formerly Deputy Secretary at the Department of Agriculture (Fig. 1). The panel and audience discussed whether there is really a struggle between scientists and policy-makers in bringing the results of research into the policy domain.

The conference also saw the official launch of the Atlas of Living Australia's PhyloLINK tools (Fig. 2). They allow users to explore data by connecting phylogenetic trees with trait data, occurrence data, and even environmental data from the points of occurrence.

On Wednesday, lichenologist Emeritus Professor Jack Elix was presented with the Nancy T. Burbidge Medal in acknowledgment of his life's work. He undertook pioneering research into the chemical signatures of lichens which are now routinely used as taxonomic characters. He has also made significant contributions to an understanding of the systematics of the world's largest lichen family, Parmeliaceae, of which he is the world expert. The lecture associated with the medal presentation was given by Gintaras Kantvilas, who provided an insightful review of lichenology and in particular the novel and fundamental contributions that Jack Elix made in Australia and around the world. A memorial plaque for Hansjörg and Marlies Eichler was unveiled in the Australian National Botanic Garden later on the same day. The pair had a huge influence on Australian systematic botany and inspired and generously nurtured many currently active taxonomists, allowing the Society to provide support for systematic research via grants from the Hansjörg Eichler Scientific Research Fund (http://www.asbs.org.au/hesrfund.html). Finally, a field trip and two training workshops took place on Thursday.

Figure 2: Temi Varghese of the Atlas of Living Australia team demonstrating new data exploration tools to conference delegates. Photo: Murray Fagg.

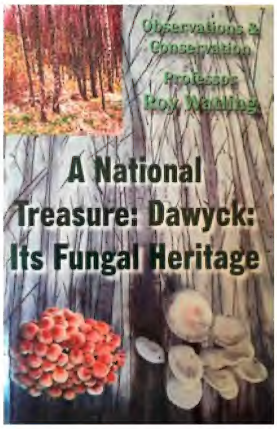
With a focus on collections science, genomic data, and online floras, the ASBS 2015 conference combined what are perhaps the three most rapidly developing areas affecting phylogenetics, systematics and taxonomy. It also became clear that it is the increasing integration of these fields that will allow novel research questions to be asked and answered that will transform our ability to characterise biological diversity. Open access to digitised specimen data and genetic data enriches online floras and identification tools. Conversely, genomic sequencing approaches have started to unlock previously inaccessible secrets of herbarium specimens, sometimes from minute amounts of degraded DNA. Plant systematics is becoming ever more integrated and data are becoming ever more easily accessible, accruing benefits to end users of this research including other scientists, conservation managers, and plant enthusiasts.

The conference was generously supported by the Atlas of Living Australia, the Australian Biological Resources Study and Bush Blitz, the Australian Network for Plant Conservation, the Centre for Biodiversity Analysis, CSIRO, and Transport by George!. Additional information is available at the conference website at www.asbs.org.au/cbr2015.

Book reviews

A national treasure: Dawyck: its fungal heritage. Observation & Conservation.

by Roy Watling
A.H. Stockwell, Ifracombe. 2015. 215 pp. ISBN 978 – 0– 7223 – 4538.2 paperback £10.95


Observations & Conservation
Professor Roy Watling
A National Treasure: Dawyck: Its Fungal Heritage

Dawyck is a property in the Southern Uplands of Scotland, in the Tweed Valley, approximately 45 km from Edinburgh. Climatically it has an almost continental climate and is situated about as far from the ameliorating effects of proximity to the sea of anywhere in southern Scotland. There is a long history of the owners of the property planting introduced trees, starting with St James Veitch in 1650, followed from 1691 by the Naesmyth family and again from 1897 by the Balfour family. The Balfours introduced many plants from North America and the Far East, and, in particular, large numbers of Rhododendron species, underplanted beneath the trees.

On the 14th and 15th of January 1968, a major storm struck Dawyck, felling a large number of trees and imposing financial pressure on the owners. Ten years later the Balfours negotiated transfer to the nation, and Dawyck came into the guardianship of the Royal Botanic Garden, Edinburgh (RBGE). The author of this remarkable book points out that the 1968 storm was only one such event that has influenced the garden during its history – highlighting the importance of rare climatic events in shaping ecosystems, a phenomenon not unique to southern Scotland.

Roy Watling was a mycologist at the RBGE for many years, and is the doyen of fungal conservation in Britain.

Since the estate became part of the network of Scottish botanic gardens a great deal of work has been dedicated to the management of the ageing population of significant trees species, ensuring their long-term survival. Since 1992 the adopted policy for new material is to concentrate on rare or threatened species grown from seeds collected on RBGE expeditions around the world. Dawyck is now extremely significant for global plant conservation.

Dawyck is a major research facility, and one of the ongoing projects has been to understand fungal ecology and to record the interactions between fungi and other organisms, both plant and animal.

This well illustrated book, depicts Watling's enthusiasm for fungi and clearly documents the enormous diversity of fungi within a small area, and the great variety of ecological niches in which they occur. Most of the general public would not have been aware that there are aquatic moulds occurring in streams and other wet habitats. Fungi have a vital role as saprophytes in ecosystems, but for the fungi, nutrient cycling would be very limited. Other fungi form a range of mutually beneficial associations with other species or are pathogens. The opportunity to study a site over a long period of time has enabled trends in abundance and changes in distribution to be documented. Given the long history of vascular planting introductions to the site, it is unsurprising that there are also many species of introduced fungi. Other non-pathogenic fungal species show changes in distribution and abundance because of human activities – an example in the United Kingdom being the False Morel (*Gyromitra esculenta*) which was previously rare but has become more common in urban areas as woodchips are increasingly used in horticulture.

Watling also discusses the importance of making available a range of interpretive material on fungi to be made available within the visitor centre and on signage.

The book is not directly relevant to Australia, but is important as an exemplar – illustrating the diversity and fascination of fungi and the importance of fungal conservation. It also raises interesting questions, including how many species of fungi have been introduced into Australia and how have horticultural, agricultural and forestry activities changed the distribution of species within Australia? I would hope that at least some Australian institutions might choose to follow the example of Dawyck and highlight fungi and their role in our ecosystems.

Paul Adam. School of BEES, University of New South Wales (UNSW)

Workshop report

Rangelands Paddock Walk at Booroorban, South of Hay

SALLY WARE[1] AND MARTIN DRIVER[2]

[1]Senior Land Services Officer, Riverina Local Land Services, Hay, [2]ANPC Project Officer.

Following the success of a Rangelands Paddock Walk held at Hay in early October last year after a productive wet winter, a second Walk was organised for the end of March at Booroorban, a location approximately 30 km south of Hay. This time the landscape showed the effects of a long hot and dry summer with a four-month gap since the last effective rain.

As with the first Walk, ANPC Project Manager and local Conargo property owner Martin Driver was the principal speaker. The day started with the fifteen participants meeting at the Royal Mail Hotel at Booroorban, followed by refreshments and a native plant and a rangelands plant identification resource display discussed before the participants travelled out to local property Thalaka, which had been recently purchased by the Simpson family.

Inspecting a Quondong tree (*Santalum acuminatum*) on the edge of a Nitre Goosefoot swamp during a recent Rangelands Paddock Walk near Hay. Photo by Annabel Lugsdin

First viewing point at Thalaka was a predominant stand of Bladder Saltbush (*Atriplex vesicaria*), with discussion focused on a boundary fence line that showed a multi-decadal grazing pressure forced vegetation change from Bladder to Dillon Bush (*Nitraria billardierei*). Next stop was to view a sandhill vegetation community that included Yarran (*Acacia melvillei*), Silver and Hooked Needlewoods (*Hakea leucoptera* and *Hakea tephrosperma*), Butterbush (*Pittosporum angustifolium*), Emubush (*Eremophila longifolia*), Narrow Leaf Hopbush (*Dodonaea viscosa* subsp. *angustissima*), Ruby Saltbush (*Enchylaena tomentosa*), Punty Bush (*Senna artemisiodes* subsp. *coriacea*), Thorny Saltbush (*Rhagodia spinescens*) and Western Boobialla (*Myoporum montanum*). From here we moved to a Rosewood community (*Alectryon oleifolius*) situated on the edge of a swamp containing Nitre Goosefoot (*Chenopodium nitrariaceum*) and Lignum (*Muehlenbeckia florulenta*) and an unexpected Flax-Lily or *Dianella* sp. protected by the lignum. On the northern side of the swamp, on a small rise, were some Quondong (*Santalum acuminatum*) trees that had one stage had been protected from grazing with netting guards to allow them to reach maturity and set fruit.

Returning to the homestead for a lunch break and discussion, the group also viewed a Miljee (*Acacia oswaldii*) tree and Cooba (*Acacia salicina*) trees or native willows around the garden yard.

Following the success of the last two Paddock Walks, a third Walk is planned with Martin Driver in the Booroorban (NSW) region further focusing on management of the sandhill vegetation communities following a significant rainfall event, hopefully before June 30 this year. There was also a significant number of people interested in participating with seed collection, propagation and re-establishment of a range of declining species like Quandong, Rosewood and Emubush. Interested people can contact Sally Ware by email at sally.ware@lls.nsw.gov.au or by mobile 0429307627 or Martin Driver by email at projects@anpc.asn.au or by mobile on 0400170957.

Research Roundup

COMPILED BY KIRSTEN COWLEY

Centre for Plant Biodiversity Research, Canberra. Email: Kirsten.Cowley@csiro.au

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Dr David Kendal
University of Melbourne

Dr Paul Gibson-Roy
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Ms Leonie Monks
WA Dept of Parks and Wildlife

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The endangered Caladenia fulva (Tawny Spider-orchid) is only known to occur in the Stawell area in the Victorian goldfields region. Photo credit: Noushka Reiter
Pelargonium striatellum (Omeo Stork's-bill) is known from only one population in Victoria at Lake Omeo, and four locations in southern NSW. Photo credit: RO Makinson